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WATER RESOURCES STUDY FOR METROPOLITAN CHESTER CREEK BASIN, PEN--ETC(U)
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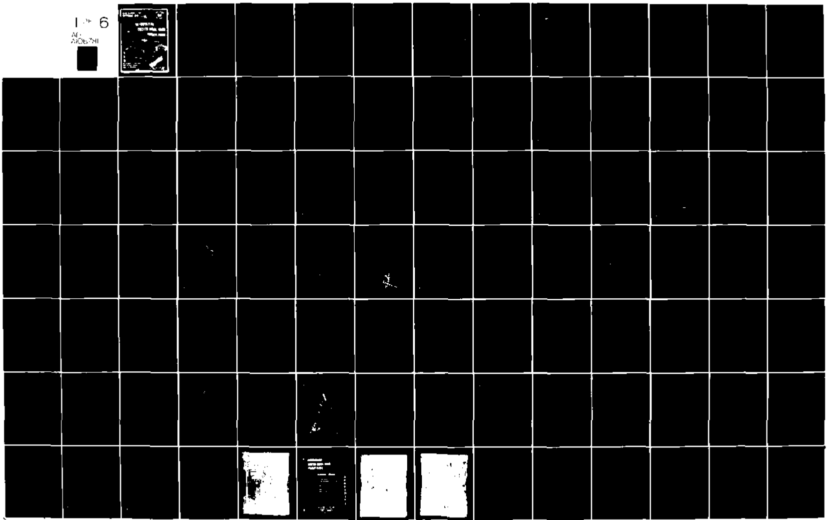

WATER RESOURCES STUDY
SEPTEMBER 1978

LEVEL II

AD A106781

# METROPOLITAN CHESTER CREEK BASIN PENNSYLVANIA

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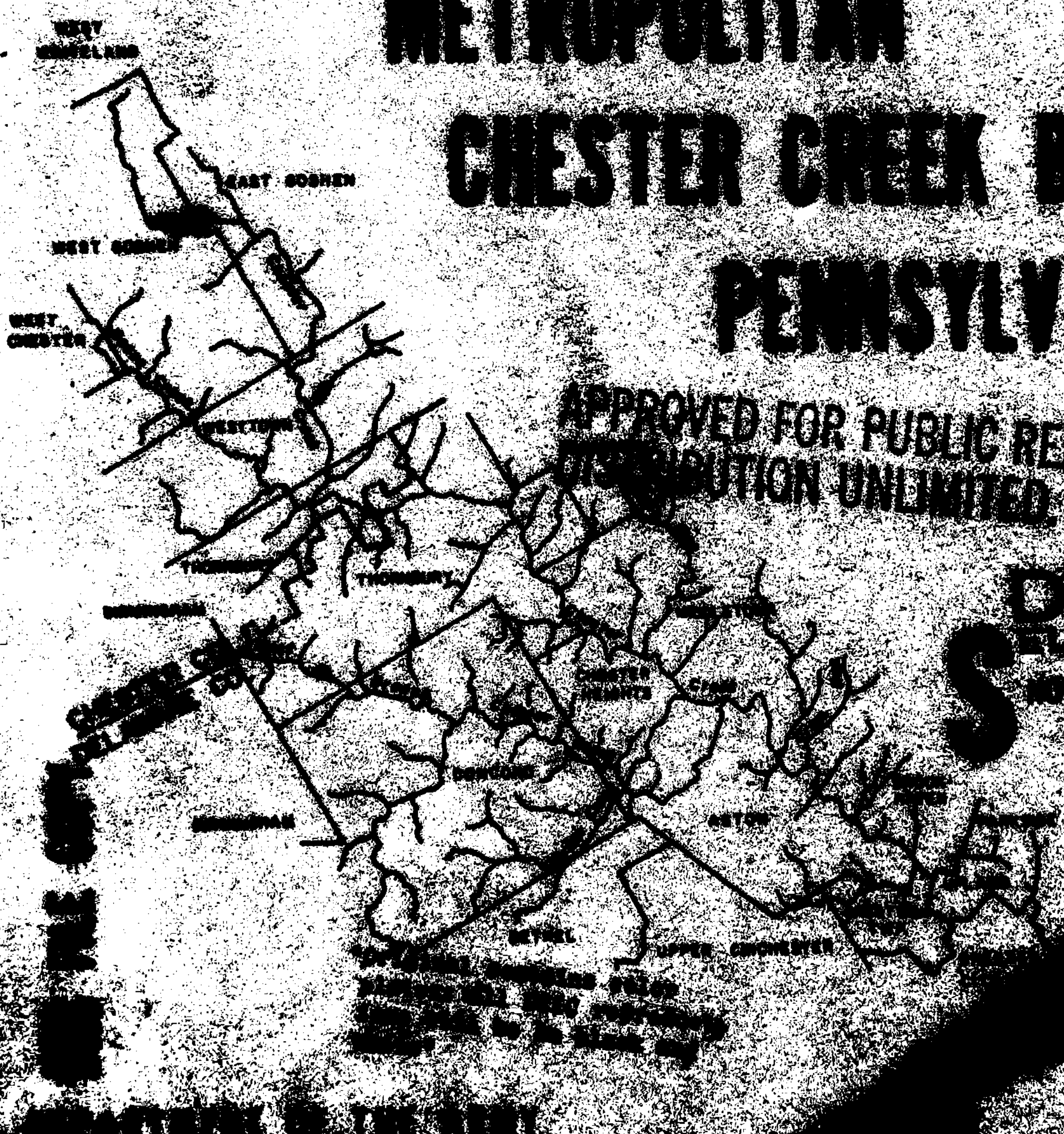


DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT
CORPS OF ENGINEERS

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# REPORT DOCUMENTATION PAGE

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| | |
|---|---|
| 1. REPORT NUMBER | DAEN/NAP-12000/WRS-78/09 |
| 2. GOVT ACCESSION NO. | AD-A106 781 |
| 3. RECIPIENT'S CATALOG NUMBER | |
| 4. TITLE (and Subtitle) | Water Resources Study for Metropolitan Chester Creek Basin, Pennsylvania , |
| 5. TYPE OF REPORT & PERIOD COVERED | Water Resources Study |
| 6. PERFORMING ORG. REPORT NUMBER | |
| 7. AUTHOR(s) | |
| 8. CONTRACT OR GRANT NUMBER(s) | |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS | US Army Engineer District, Philadelphia<br>US Custom House-2nd & Chestnut Streets<br>Philadelphia, PA 19106 |
| 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS | |
| 11. CONTROLLING OFFICE NAME AND ADDRESS | 11 |
| 12. REPORT DATE | Sept 1978 |
| 13. NUMBER OF PAGES | 150 |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) | 537 |
| 15. SECURITY CLASS. (of this report) | Unclass |
| 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE | |

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

| | |
|---|---|
| Chester, PA | Flood Plains |
| Floods | Hydrology |
| Chester Creek, PA | Flood Control |

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this study was to investigate solutions for water resources problems in the Metropolitan Chester Creek Basin in Chester and Delaware Counties, PA. It focused primarily on flood control and flood plain managment. Forty-seven plans for preventing or reducing flood damages were considered. These were both of a structural and non-structural nature.

The resources, economy, environmental aspects, water supply and flooding

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problems of the study area were identified. Maps of the floodplain, hydrographs and flood profiles were presented with the data.

## SYLLABUS

The purpose of this Congressionally authorized study was to investigate solutions for the many water resources problems in the Metropolitan Chester Creek Basin in Chester and Delaware Counties, Pennsylvania. In compliance with local desires, the study was redirected from a comprehensive undertaking to a flood control and flood plain management effort.

Periodic flooding has occurred since the Basin was first settled in 1643. The worst flood occurred on 13 September 1971. It flooded over 130 businesses and 730 homes, caused $26,138,000 in damages, and resulted in the loss of eight lives. Total average annual damages in the Basin are estimated at $720,300 in 1978 and projected to reach $1,199,000 by 2035. About 66% of the projected increase is due to increases in storm runoff from future land development of the upland areas. Over half of the damages occur in the older communities of the City of Chester, Upland Borough and West Chester Borough.

Forty-seven plans for preventing or reducing flood damages and the threat to human life were considered. These included both structural and non-structural measures applied both on a basin-wide basis or individually at local problem areas. An iterative process was employed in the development and evaluation of plans. Thirty-five plans were eliminated from further consideration because either they were not practical solutions, not very effective in solving the flooding problems, not economically justified, or clearly a non-Federal responsibility.

Twelve plans were identified as having potential for development as solution to the flood problems. These were coordinated with State, County and municipal officials and the general public. Only two plans for the City of Chester received local support. The rest were eliminated by local interests due to a large amount of property relocations involved; protection of only a few properties was not considered appropriate by local municipalities; more efficiently implementable by the local communities themselves; high non-Federal cost required; or the aesthetically offensive or phycologically confining nature of the large protective structures.

Further investigations of the two plans in the City of Chester resulted in large increases in costs and no increases in benefits. The plans were not economically justified.

The District Engineer recommends that no improvements for flood control be authorized by the United States at this time.

The District Engineer has concluded that Chester and Delaware Counties and their municipalities should develop a flood plain management program for the Basin, and that they should establish a maintenance program to clear debris and sediment from under bridges across the Chester Creek and tributaries.

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# WATER RESOURCES STUDY
# FOR
# METROPOLITAN
# CHESTER CREEK BASIN
# PENNSYLVANIA

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WATER RESOURCES STUDY

SEPTEMBER 1978

# METROPOLITAN CHESTER CREEK BASIN PENNSYLVANIA

THE STUDY AND REPORT

Flooding in the Chester Creek Basin is frequent and results from localized heavy rainfall which causes flash floods. The worst flood occurred on 13 September 1971. Over 130 businesses and 732 homes were flooded. Eight lives were lost. The Metropolitan Chester Creek Basin Study was authorized as a result of this flood.

The Chester Creek is located entirely within southeastern Pennsylvania as shown in Plate 1. Chester Creek is a tributary to and makes it confluence with the Delaware River at the City of Chester, which is the major urban center of the Chester Creek Basin.

## PURPOSE AND AUTHORITY

The study was authorized by resolutions of the Senate and House of Representatives Committees on Public Works, adopted 2 November and

2 December 1971, respectively. Under these authorities, the purpose of the "Metropolitan Chester Creek Basin Study" is to report findings from investigations to determine whether recommendations should be made for providing improvements in the interest of flood control, regional water supply and wastewater management, water quality control, recreation, and other measures for the enhancement and protection of the environment.

During the course of the study the study purpose was redefined to include only investigations of flood water and flood plain management problems.

## SCOPE OF THE STUDY

The study was initiated in May 1973 as part of the Corps Urban Studies Program. During the period from May 1973 to November 1974, Stage I investigations were conducted. This work included intense coordination with local interests to define the water resources problems and needs, and interim local flood control studies.

Based on local desires and initiation of several Commonwealth of Pennsylvania water resources studies, the Chester Creek Study was re-oriented from a comprehensive Urban Study to a survey level flood control study. The Study's primary goal was to solve only flood water and flood plain management problems. A secondary goal was to identify any flood control plans which can also be developed for water supply and recreation.

Numerous field investigations were carried out to identify problems and needs, to quantify flood damage potential, and to formulate and evaluate flood control plans. Existing data was used wherever possible. Basin hydrology and hydraulics were modeled using the latest available computer techniques.

All reasonable structural and non-structural flood control plans were considered. However, due to the lack of economic justification or local sponsorship, not all plans were investigated at the same level of detail.

Investigations of alternative plans were conducted through several planning cycles. In each successive cycle fewer plans were considered but the level of detail increased. Each plan underwent this process until it reached the point where it was shown to be economically unjustified, not implementable by the Federal Government, or not supported by any non-Federal Government.

## STUDY PARTICIPANTS AND COORDINATION

The Corps of Engineers, Philadelphia District was responsible for conducting and coordinating the study and preparing the report. During the study, the Corps worked closely with representatives of the Pennsylvania Department of Environmental Resources; the Delaware Valley Regional Planning Commission (DVRPC); the Delaware County Planning Commission; the Chester County Water Resources Authority and Chester County Planning Commission; each municipality with a major flood problem, particularly the City of Chester and Chester Township; and the U.S. Fish and Wildlife Service.

The study was also coordinated with appropriate Federal, State and County agencies, all the municipalities, special interest groups, and the general public.

An initial public meeting was held on 19 November 1974. A Stage II public meeting was held on 27 April 1977, and a final public meeting was held on 30 August 1978 to report that no projects could be recommended for development by the Corps of Engineers. Workshops were used throughout the study to involve municipal representatives and special interest groups. Eleven issues of the Study newsletter UPDATE were published.

## THE REPORT

The results of the study are presented in four parts: the main report and three appendices. The main report is a non-technical document which presents a broad view of the overall study and findings. Appendix 1 is a technical report which provides greater technical detail on the study area; problems and needs; solutions considered; and the conduct of the investigations. It is the key document for the technical reviewer. Appendix 2 reports public involvement during the study and contains pertinent correspondence relative to the study. Appendix 3 presents the reports of other agencies regarding this study and report.

## PRIOR AND CURRENT STUDIES

There have been many study efforts for satisfying water resources problems and needs in the Chester Creek Basin or the region of which it is a part. These include Federal, State, regional, county and municipal efforts and even some by private interests. A listing and summary of the more pertinent studies is presented in the following paragraphs.

The Philadelphia District prepared The Comprehensive Survey of the Water Resources of the Delaware River Basin (House Document No. 522 of the 84th Congress, 2nd Session). This plan for the coordinated long range development of the water resources of the Delaware River Basin was authorized in August 1962. Recommendations were made for construction of a number of multi-purpose reservoirs throughout the Basin. No recommendations were made for the Chester Creek Basin.

The Philadelphia District prepared a Flood Plain Information Report on Chester Creek, Delaware County, Pennsylvania for the Delaware County Planning Commission in December 1966. It presented information about both past floods in the area and potential future floods along Chester Creek in Delaware County. The data on future floods is no longer up-to-date due to changes in hydrology and hydraulics.

In 1951, the Philadelphia District prepared the Project Report of Flood Control, Chester River, Chester, Pennsylvania. It resulted in the construction of levees and floodwalls on the right bank of Chester Creek at Fyre Park in the City of Chester. The project was overtopped by the 1971 flood, all 216 homes behind the levees and floodwalls were removed, and the area is now in recreational use.

The National Flood Insurance Program was established by the National Flood Insurance Act of 1968 to make specified amounts of flood insurance available under Federal auspices. All but one municipality (Bethel Township) in the Chester Creek Basin is participating in the program. Flood Insurance Studies have been prepared for most Basin municipalities.

The Pennsylvania Department of Environmental Resources (DER) is to develop a flexible State Water Plan for wise management of the water resources to meet present and future needs of the people of Pennsylvania. A draft report on the results of the studies in sub-basin 3 which includes the Chester Creek Basin was completed in September 1977. The final report is scheduled to be completed in 1978.

DER is developing a Comprehensive Water Quality Management Plan (COWAMP). In southeastern Pennsylvania, COWAMP has been combined with the Section 208 Water Quality Management Plan being conducted by DVRPC. COWAMP/208 issued a report on alternative plans and choices in September 1977 and is scheduled to make its final recommendations to the Governor of Pennsylvania in mid-1978.

## RESOURCES AND ECONOMY OF THE STUDY AREA

The Chester Creek Basin is located in southeastern Pennsylvania. Chester Creek is a tributary of the Delaware River and makes its confluence with the Delaware River at the City of Chester. The Basin is located within the suburbs of Philadelphia and within its Standard

Metropolitan Statistical Area (SMSA). The Basin lies within the Delaware Valley Region, which encompasses the SMSA's of the Cities of Philadelphia and Trenton. The region radiates from Philadelphia and includes five counties in Pennsylvania and four in New Jersey.

The Chester Creek Basin (67.9 square miles) lies within Chester (22 square miles) and Delaware (45.9 square miles) Counties. There are 21 municipalities which are either totally or partially located in the Chester Creek Basin. These municipalities are listed and located on Plate 2. The major urban centers are the City of Chester and the Borough of Upland in Delaware County, and a portion of the Borough of West Chester in Chester County.

## ENVIRONMENTAL SETTING AND NATURAL RESOURCES

PHYSIOGRAPHY. Chester Creek Basin tributaries originate in an area which is characterized by a gently rolling countryside with occasional low hills and ridges which run in a northeast to southwest direction. The streams generally run at right angles to the ridges as they flow in a southeasterly direction to the Delaware River.

The headwater areas have undergone prolonged erosion resulting in much of its former plateau-like appearance being modified to slopes and gently rounded hills. Erosion has also affected the area along the Delaware River where beds of unconsolidated or poorly consolidated sediments have been largely removed down through the ages.

SOILS. The soils in the Chester Creek Basin are typical of the northeastern United States. In the extreme upper headwaters the soils are either moderately deep, well drained, silty, channery, and gravelly; or they are shallow to deep, silty and channery soils on grayist-brown schists and gneiss. The soils in the lower portion of the Basin are of the variety of silt, sands and gravels deposited from sedimentation. All of the Basin soils yield easily to erosion.

GEOLOGY AND MINERALS. Most of the Chester Creek Basin is underlain by metamorphic rock formations which have evolved from older igneous rocks. The major metamorphic rocks in the Basin consist of schists and gneisses. Smaller amounts of non-metamorphic rocks such as gabbro, quartzite and limestone can also be found. Coastal plain sediments underlie the southeastern portion of the Basin near the Delaware River. These deposits consist of sand, silt and clay with sand and gravel beneath.

There are no significant deposits of metallic ores in the Delaware County although chrome and copper have been worked in the past. The County's significant mineral wealth lies in its non-metallic resources and these include clay, sand, and gravel, the pegmatite minerals and

stone products. From the rocks of Chester County have come ores of iron, copper, lead, and zinc as well as numerous non-metallic minerals. Two mineral extraction sites and one abandoned quarry lie within the Basin.

CLIMATOLOGY. In the study area winters are generally mild with little snow. Temperatures average about 33°F. Summers are frequently hot and humid, but are occassionally dry resulting in drought. Summer temperatures average about 76°F. Winter storms are often caused by low pressure areas traversing the Atlantic Coast resulting in heavy rains. Occassionally cold fronts from the west and the Great Lakes will cause heavy rains. During the summer, rainfall is usually caused by the westward movement of weather fronts. However, on occasion a tropical storm may cause severe rainfall by picking up moisture from the Atlantic Ocean.

Precipitation is evenly distributed throughout the year. The normal annual precipitation is about 42.9 inches with the minimum annual precipitation of 29.3 inches recorded in 1922, and the maximum annual precipitation of 55.3 inches recorded in 1873. Approximately 48 percent of the annual precipitation occurs during the period from May through September. The maximum 24 hour precipitation was 5.45 inches during the period 11-13 September 1960. The normal annual snowfall totals about 22 inches. Flooding in the Chester Creek Basin requently results from localized heavy rainfall. This intense rain, falling in the relatively long and narrow drainage area with steep side slopes, produces flash flooding.

Excessively high or low temperatures as well as prolonged periods of either hot or cold weather are relatively infrequent. About 4 percent of the year the temperature is over 85°F and about 4 percent of the year the temperature is below 25°F. Sixty-three percent of the year the temperature is between 45°F and 85oF.

The area's prevailing winter winds are from the northwest and from the southwest during the summer. The area is upwind from major air pollution sources, and because of wind direction and basic land form, can be considered to be well ventilated. Some air pollution may occur in the fall during prolonged periods of temperature inversions and low winds, permitting some smog accumulation.

GROUND AND SURFACE WATERS. Groundwater is one of the most important natural resources found in the Chester Creek Basin. The Chester County portion of the Basin is underlain by limestones and shales. Groundwaters are a source of water supply. The Delaware County portion of the Basin is densely urbanized and surface water systems supply is the source of water.

There are two critical aquifer recharge areas in the Basin. One area consists of the eastern two thirds of West Whiteland Township and the northeastern and northwestern portions of West and East Goshen Townships, respectively. The other area encompasses all of the City of Chester and the southern half of Chester Township.

The Chester Creek Basin is drained by main stem Chester Creek and its tributaries. The East and West Branches are the largest tributaries. There is a USGS stream gaging station located on Chester Creek just downstream from Dutton Mill Road in Brookhaven Borough. The gage has a drainage area of 61.1 square miles. Gage records go back to 1931. The average flow is about 83 cubic feet per second (cfs). The minimum recorded flow was only 0.3 cfs.

The worst flood recorded by the gage was on 13 September 1971 when the flow peaked at about 21,000 cfs. The second worst flood was on 25 November 1950 and produced 14,400 cfs. Both caused considerable flooding of low lying areas.

WATER QUALITY. The Chester Creek Basin waters are generally protected for the following uses:

Aquatic Life
- Warm water fish
- Trout (stocking only)

Water Supply
- Domestic
- Industrial
- Livestock
- Wildlife
- Irrigation

Recreation
- Fishing
- Water contact sports
- Natural uses

Other
- Power
- Treated Waste Assimilation

Water quality within the Chester Creek Basin is good. Even some of the problem pollutants seem to be improving. The one reach which seems to have a very serious water quality problem is Goose Creek, where dissolved oxygen, dissolved solids, and bacteria counts fail to meet standards. Also, in the lower-tidal portion of Chester Creek in the City of Chester, threshold-odor exceeds standards.

FLORA. The natural cover of the area is hardwood forests, mostly deciduous hardwoods. The remainder of the area is either used for farming, open pastures, or urban uses. There are no Federal or State forest lands in the Basin. A survey conducted by the U.S. Forest Service of trees indicated that southeastern Pennsylvania is losing forests at a rate of 4% acreage per decade. This loss can be having an adverse impact on watershed management since forests store and retard storm water runoff.

From the standpoint of ecological importance, the only significant vegetation in the Basin is a marsh located along the East Branch Chester Creek near Cheyney, Pa. The major value of the remaining woodlands are their aesthetic or recreational potential. However, most of the woodlands are in private ownership, and their usage by the public, particularly for recreation, is limited. The majority of significant woodland acreage remaining in the Basin is along the streams or on steeper sloped areas. Orchards and nurseries are important to the overall agricultural activity

for each county, however these are not an extensive portion of the Basin's tree coverage.

FAUNA. Wildlife in the area is varied and typical of northeastern United States. Because the woodland of the area is scattered throughout the Basin, the wildlife which use the woodlands for protection and cover is also scattered. Urbanization is reducing or eliminating natural habitats available to indigenous wildlife. Species which cannot adjust have moved to the quieter natural areas in the upper portion of the Basin. Others can adapt to a limited suburban development and will remain, but in reduced numbers.

No known threatened or endangered species of fish, reptile, bird, mammel or amphibian is found in the Basin. However, the Basin is included in the general range of the southern bald eagle, American peregrine falcon, and the shortnose strugeon. The ranges of the American osprey, Ipswich sparrow, and the bog turtle include the study area but are considered rare locally.

Fishery resources within the Basin consist of both warmwater and coldwater species. Streams suitable for trout are found in the upper reaches of the Basin. Warmwater stream fisheries occur throughout the remaining streams, but are limited due to pollution. Fishing opportunities are extremely limited in relation to high demands in the area. There is no commercial fishing in the Basin. No anadromous fish use Chester Creek.

OPEN SPACES. Almost 64% of Chester County and 78% of the Delaware County portions of the Basin are classified as open spaces. At first, this appears abnormally high for an urbanized area. However much of this is actually utilized as farm and extremely low density residential lands, instituional uses and major cemetaries.

## HUMAN RESOURCES

There is a fairly large disparity between the older established Basin communities and those currently undergoing urbanization. This disparity exists in population growth, density, and racial and economic composition.

HISTORY OF THE PEOPLE. Chester County was one of Pennsylvania's original counties established by William Penn in 1682. The City of Chester can trace its beginnings to the settlement called Upland established in 1643. William Penn arrived at Upland in the fall of 1682; changed its name to Chester; and on December 4th, the First Assmebly of Pennsylvania was convened at Chester. Chester (Upland) was the county seat for all government activity for over a century, but as the county became settled residents began insisting on a more central location.

As testimony to the rich history of the Basin are the 114 sites which are on the State's list of historic sites. Nine of the sites are listed in the Nation Register of Historic Places.

PEOPLE OF THE BASIN. Chester and Delaware Counties' populations in 1970 were 277,746 and 601,762, respectively. An estimated 75,762 of these people (8.6%) live within the Basin. Except for the City of Chester, most of the communities of the Basin have had a steady increase in population which is expected to continue in the future.

The population characteristics of the Basin are very different from Chester and Delaware Counties as a whole. The black population of Chester and Delaware Counties is slightly more than 7% of the total. About 24% of the Basin's population is black. Blacks are concentrated in older and poorer urban centers. The age group in the Basin also tends to be younger than the median age in Delaware County but more closely approximates that in Chester County.

THE LABOR FORCE. The people in the Basin municipalities account for 12.4% of the total labor force in Chester and Delaware Counties. The labor force participation rates compared to the State-wide average are:

| | Both Sexes (percent) | Male (percent) | Female (percent) |
|---|---|---|---|
| Pennsylvania | 56.4 | 75.8 | 39.3 |
| Chester & Delaware (Total) | 58.9 | 79.1 | 40.1 |
| Chester Creek Basin | 57.9 | 77.1 | 40.0 |

COMMUNITY COHESION. The Basin communities are well established. There are four major cultural facilities, six major libraries, fifteen different religious denominations, and over twenty-five major associations and organizations in the Basin.

The Basin is very stable. On the average, over 90% of the owner-occupied residences have been occupied by the present owner since prior to 1970. Also over 40% of renter-occupied residences have been occupied by the present rentor since prior to 1970.

EDUCATION. The Basin's commitment to education is above average. Expenditures for education are above County averages. Faculty experience averages about 10 years. The pupil to teacher ratio ranges from about 17 to 22.

## DEVELOPMENT AND ECONOMY

The first industry in the Basin was established in 1810. There were also about 90,000 acres of cultivated farmlands. At one time there were six shipyards located on the banks of the Delaware River. In early times, the area had an intensive manufacturing base with an extensive developed agricultural base. In recent history many of these industries have declined, especially in the older more urban areas. However, future development and economic growth is expected to occur in the less developed middle portions of the Basin.

ECONOMIC BASE. About 11.2% of Delaware and Chester County's land area is in the Basin. The Basin has 8.6% of the population, while its industries account for 23.1% of the total employment of the two counties. Chester County ranked 16th in the State in 1972 with 30,918 employees and Delaware County ranked 10th with 41,795. Of these, 4,065 and 12,728 respectively, were actually employed in the Chester Creek Basin; totalling 16,793 employees working for 166 establishments.

Basin economic activities result in about $708,545,000 in production and $339,025,000 in value added. The top six industrial groups provide 78% of the value of protection within the Basin and 80% of the value added by manufacturing within the Basin.

The two most labor intensive industries, transportation and fabrication metals amounted to 33% of the employment within the Basin and 26% of value added by manufacuturing. The two most capital intensive industries, paper and chemicals, amounted to 23% of the employment and 40% of the value added by manufacturing. In 1969, Chester County was number 1 in the nation for value of nursery and greenhouse products sold. Chester County is also known as the Mushroom Capital of the World because it is the nation's leading producer of mushrooms. In 1969, Delaware County ranked 4th in the State in manufacturing. Durable goods manufacturers employ two-thirds of the manufacturing work force in the county, but because of several large capital intensive industries (paper, chemical, and petroleum), durable goods have less than 50% of the value of production.

Mean family income for the Basin was $11,330 in 1970 compared with $10,999 for the entire United States. There is considerable variation in mean family income both between the counties and the major urban areas. Median family income in the area was $11,233 per year. Some 27% of the families in the Basin have an income of more than $15,000. About 15% of the families having incomes less than 125 percent of the poverty level, and 8% have incomes less than 75 percent of the poverty level.

ECONOMIC TRENDS. Chester County has benefitted greatly from the migration of industry and population to the suburbs. Its industrial mix is relatively good, with biggest employers being primary metals and food and and kindred products. Trends in Chester and Delaware Counties on employment, wages and salaries and value of production are shown on Plate 3. Employment, wages and salaries, and value of production level dropped between the late 1960's and early 1970's. Currently all show strong upward trends. Chester County is rated 4th in the State in level of economic development and second according to economic growth. Delaware County was rated 2nd in the State in level of economic development but only 29th according to economic growth.

TRANSPORTATION FACILITIES. The Chester Creek Basin is in an area with excellent transportation facilities. There are major rail lines and interstate highways serving the area. The Basin is adjacent to the Delaware River which provides waterborne transporation and is near the Philadelphia International Airport.

There is an extensive State and Federal highway network in the Basin. The City of Chester is served by two rail lines: ConRail and Chessie. Both have freight lines through the City which parallel the Delaware River. ConRail also provides freight service from Philadelphia to West Chester and north. The Southeastern Pennsylvania Transportation Authority (SEPTA) has purchased the Octoraro Branch of the Penn Central Railroad running from Lenni to Colora, Maryland for both freight and passenger service.

Passenger service to Philadelphia (and points north) and to Wilmington, Delaware (and points south) is provided with connections to Amtrak at Philadelphia and Wilmington. SEPTA also operates a light rail facility between Media and Philadelphia and a network of bus routes in Delaware and Chester Counties connecting other Counties and Philadelphia.

URBANIZATION. The Delaware Valley Region is being developed at an increasing rate*. The character of this development is similar to that of most urbanizing areas and includes many major new residential communities, commercial shopping centers and malls, and industrial parks.

Land use patterns in 1940, existing and 2000 are presented in Plates 4, 5, and 6, respectively. As can be seen by these plates, development, in the past, has eminated from the two urban centers, the City of Chester and Borough of West Chester. Future development is expected to concentrate on the middle portions of the Basin, expecially the West Branch Chester Creek area.

* "Urbanization" refers to a condition in which a natural terrain is developed for residential, commercial, & industrial purposes. Urbanization directly effects climatic & hydrologic conditions, factor such as cultural, recreation & business activities of the population; land cover & wildlife; and the amount of required services, such as water supply & wastewater.

## PROBLEMS AND NEEDS

There are many water and water related problems in the Chester Creek Basin. Development and growth have placed heavy demands on the ability of local governments to meet these needs. Problems have been compounded by the redistribution of population from city to suburbs.

There is much concern over the Basin's water problems. There have been and there are currently many studies being devoted by others toward solving these problems.

Five water resources and land related issues which were identified as Basin problems are as follows:

Water Quality and Wastewater Management
Water Supply
Recreation
Erosion and Sedimentation Control
Flood Water and Flood Plain Management

### WATER QUALITY AND WASTEWATER MANAGMENT

There are many unresolved water quality and wastewater management problems in the Basin. They include the need for:

Higher levels of point source treatment to meet low flow criteria for dissolved oxygen, nitrate-nitrogen, and un-ionzed ammonia

Stormwater runoff control in urban and newly developing areas

Erosion and sedimentation control of construction sites and road drainage

Quality control of sewer overflows

Prevention of residual wastes, groundwater contamination and spills

Elimination of malfunctioning septic systems

Elimination of water quality problems resulting from agricultrual activities.

STATUS OF EXISTING AND FUTURE PLANS. The Delaware County Regional Sewerage Plan (DELCORA) completed in November 1972, considered problems and alternative solutions on a multi-county or sub-regional basis. Pennsylvania's Comprehensive Water Quality Management Plan (COWAMP/208) is also considering the problem in the entire southeastern portion of Pennsylvania. Both efforts include the entire Chester Creek Basin.

As a result of DELCORA's plans, many of the existing municipal discharges have been regionalized into a county-wide system. These plans were initiated prior to the start of the COWAMP/208 work. They are well on their way toward implementation. The COWAMP/208 study is incorporating these DELCORA studies. Plans are being reviewed by COWAMP/208 in light of new population projections and alternative approaches to point source management. Point source technical alternatives currently being investigated by COWAMP/208 include: land application; individual treatment plants; subcentral arrangements of treatment plants; and non-sewer schemes. The COWAMP/208 report is scheduled for transmittal to the Governor of Pennsylvania for approval in mid 1978. This report will also include recommendation for disposal/reuse of sludge (landfilling land spreading, incineration), for control of pollution from intermittent point and non-point sources, and for management of wastewater facilities.

STUDY OBJECTIVES. Pennsylvania has assumed full responsibility for the development and coordination of water quality and wastewater management plans for the Chester Creek Basin. The Chester Creek Basin Study did not investigate the water quality and wastewater management needs nor did the Corps' study perform any portion of the COWAMP/208 study effort.

## WATER SUPPLY

Much of the demand for water for users in the Chester Creek Basin is satisfied by supply sources outside the Basin. Four major suppliers serve the people of the Basin. Wells, reservoirs, and direct surface water withdrawal are used in meeting water supply needs. Use ranges from 97 to 227 gallons per capita per day. Reserve storage capacity of treated water ranges from about 1.6 to 3.6 days of storage. Some of the problems relating to water supply are:

Existing sources are insufficient to meet future water supply requirements.

Locating and developing major reservoir sites is difficult. Major multi-purpose reservoirs which include water supply storage are either behind schedule or will not be constructed. Natural land areas suitable for impoundment sites have been developed; thereby, making them economically and socially infeasible.

Studies are needed of interbasin transfers of water, water renovation or reuse, flood skimming, and groundwater recharge.

Studies are needed to determine how water distribution system leaks and other losses can be reduced.

STATUS OF EXISTING AND FUTURE PLANS. Although water supply planning to some degree is being conducted by all municipalities and/or their water purveyors, the major effort in a regionalized approach is currently being undertaken by Pennsylvania in the "State Water Plan." Alternative solutions are being developed. The State Water Plan's draft report was completed in September 1977 and the final report is scheduled for completion in 1978.

STUDY OBJECTIVES. Pennsylvania is undertaking a regionalized approach to needed water supply planning in the Chester Creek Basin.

The Chester Creek Basin Study did not include any water supply studies per se. Although multi-purpose projects including flood control, water supply, and recreation were initially considered, it became obvious that water supply could only be developed at the expense of flood control. No further water supply studies were conducted.

## RECREATION

The study considered water based recreation, and related land recreation which may be developed in conjunction with a flood control project. Related land recreation would include bicycle paths, hiking trails, and picnic areas in conjunction with dry reservoirs, levees, or flood plain management.

Recreational demands of the people of the Chester Creek Basin continues to grow. At the same time, urbanization eliminates open spaces, thereby reducing opportunities for recreation. Recreational and open spaces needs of the people of the study area can not be totally satisfied within the confines of the Basin. Because of the size, complexity, or investment required for certain recreational activities, facilities must be planned on a regional basis.

There is already an existing need for picnic and beach facilities. By 1990 there will also be a need for additional areas for power boating and fishing. Open space and municipal-type needs are greater. Many municipalities can not meet recreation demands.

STATUS OF EXISTING AND FUTURE PLANS. DER, in its "State Water Plan," has inventoried recreation and open space areas in the Commonwealth; has prepared recreation plans for the Commonwealth; and has formulated planning alternatives and recommendations.

The Delaware Valley Regional Planning Commission will prepare an open space plan for the Region. This plan is to be completed in mid-1978. Delaware County and Chester County Planning Commissions have inventoried existing recreation and open spaces and have identified areas for preservation. A report titled "Delaware County Open Space, Park, and Recreation Study" is scheduled to be completed in 1979.

STUDY OBJECTIVES. Pennsylvania has assumed responsibility for needed recreational and open space planning in the Chester Creek Basin. The Chester Creek study did not include studies of the development of recreation plans for the Basin. However, the study did investigate the possibility of recreational or open space development in conjunction with flood control projects.

## EROSION AND SEDIMENTATION CONTROL

Erosion of upstream land and sedimentation in streams affect many other water resources problems including: the aesthetic quality of water; the in-stream bio-chemical process of photosynthesis; the cost for water treatment; the storage capacity of reservoirs; the flood-water and transport capacity of water courses; the navigation capacity of channels; the loss of valuable land; and the support and stability of structures.

The Creek's annual sedimentation rate is one of the highest of all tributaries of the Delaware River. The Chester Creek has an estimated annual sediment yield of 265 tons per square mile which results in 17,490 tons of sediment per year.

Sediment related problems include:

Sedimentation is one of the greatest water quality contaminants in the Chester Creek Basin. Disease germs, pecticides, and other pollutants attach themselves to the sediment particles and are transported throughout the Basin.

Siltation of waterways and impoundments has reduced their water storage capacity.

Surface and bank erosion has reduced the land's potential productivity.

STATUS OF EXISTING AND FUTURE PLANS. There are no planning activities which are primarily concerned with the erosion and sedimentation problems of the Chester Creek Basin. The Commonwealth of Pennsylvania's "Comprehensive Water Quality Management Plan" (COWAMP/208) is concerned with sedimentation but not as a primary study purpose. Sedimentation is being considered under the "non-point sources" of pollutants.

The U.S. Soil Conservation Service and Chester and Delaware Counties have been concerned with erosion of agricultural lands. County Conservation Districts try to incorporate sediment and erosion control measures under cooperative agreements with the landowners.

Under Pennsylvania's Clean Streams Law all persons engaged in land development with earth moving activities must design, implement and maintain sedimentation and erosion control plans. However, only those projects involving 25 or more acres require a permit. Enforcement of this law is difficult due to lack of a permit requirement for smaller land parcels.

STUDY OBJECTIVES. Pennsylvania has assumed responsibility for any needed erosion and sedimentation control studies in the Basin. The Chester Creek Study only considered erosion and sedimentation control problems where they are related to the floodwater and flood plain management planning.

## FLOODWATER & FLOOD PLAIN MANAGEMENT

Periodic flooding has occurred along Chester Creek since the time of the Basin's earliest settlement in 1643. Flooding did not become a major problem until flood plain lands were developed. This problem has become worse due to developments in upstream areas, causing increased runoff. Interim investigations conducted at the start of this study indicated that solutions could only be developed on a basin-wide approach and through inter-action and integration with other water resources purposes.

As shown in Table 1, flooding usually results from high intensity thunderstorms during the summer and fall months. This type of rainfall together with a relatively long, narrow, and steep basin combine to produce quick rises in water levels and high flood stages.

The lower 2 miles of Chester Creek are tidal. Flooding problems in this reach are compounded when high tides in the Delaware River occur at the same time as runoff produced by intense rainfall. However, high tides have never caused flooding problems along the Creek.

Major damage centers are shown on Plate 7. The worst flooding occurrs in the lower main-stem reaches. Flooding here is compounded by many man-made constrictions such as encroachments by dumps, landfills, and structures. There are more than 26 bridges over the first 10 miles

TABLE 1
CHARACTERISTICS OF FLOODING
CHESTER CREEK

| Flood Event | Type of Storm 1/ | Flow at Gage (cfs) 2/ | Elevations (ft.) 3/ | Damages 4/ |
|---|---|---|---|---|
| SPF | NA | 35,800 | 54.0 | $26.9 M |
| 13 Sept. 71 | HR | 21,000 | 48.0 | 17.6 |
| 100-YEAR EVENT (1%) | NA | 20,300 | 47.5 | 16.2 |
| 50-YEAR EVENT (2%) | NA | 16,000 | 44.8 | 6.5 |
| 25 Nov. 50 | HR | 14,400 | 43.7 | 4.6 |
| 25-YEAR EVENT (4%) | NA | 11,900 | 41.8 | 2.6 |
| 12-13 Sept. 60 | TS | 9,940 | 40.0 | 1.6 |
| 28 July 69 | HR | 9,560 | 39.7 | 1.4 |
| 18-19 Aug. 55 | TS | 9,380 | 39.5 | 1.3 |
| 10-YEAR EVENT (10%) | NA | 8,090 | 38.4 | 0.9 |
| 23-24 Aug. 33 | TS | 6,250 | 36.7 | 0.5 |
| 22-23 June 72 | TS | 6,180 | 36.6 | 0.5 |
| 23 July 38 | HR | 5,120 | 35.4 | 0.2 |
| 9-10 Jan. 36 | HR | 5,000 | 35.2 | 0.2 |
| 3 Aug. 50 | HR | 5,000 | 35.2 | 0.2 |
| 15 Mar. 67 | HR | 4,770 | 34.9 | 0.1 |
| 7 Mar. 67 | HR | 4,730 | 34.8 | 0.1 |
| 1 Aug. 45 | HR | 4,440 | 34.7 | 0.1 |
| Approximate Discharge causing Damages from Over-bank Flooding in Lower Reaches | | 4,000 | | 0.0 |
| Mean Annual Discharge | | 1,300 | | 0.0 |

1/ Symbols denote the following: NA is Not Applicable; HR is Heavy Rainfall; and TS is Tropical Storm.
2/ Discharges measured at the Dutton Mill Gage which is a United States Geological Survey water-stage record. Gage records exist from 1932. Discharge is measured in cubic feet per second (cfs).
3/ Elevations are in feet above mean sea level and are measured at the Dutton Mill Gage.
4/ Damage estimates are in January 1978 millions of dollars (M). These are damages which would occur if the flood occurred under 1977 Basin conditions.

of Chester Creek; most of which are major constrictions to flow.

The flood of record occurred on 13 September 1971. This flood was caused by very localized rainfall which did not affect adjacent basins. Over 130 businesses and 732 homes were flooded. Second story flooding was common. There were eight deaths. The Chester Water Authority was forced to close down its water supply treatment plant for 5 days and a "boil water" order was issued. Total floodcosts (in January 1978 dollars) were as follows:

| | |
|---|---|
| Residential | $ 6,286,000 |
| Commercial/Industrial | 17,029,000 |
| Utilities | 177,000 |
| Highway | 795,000 |
| Public | 515,000 |
| Flood Emergency | 1,336,000 |
| TOTAL | $26,138,000 |

Existing average annual damages total about $720,300. An approximate breakdown of these damages by community is as follows:

| Municipality | Distribution of Average Ann. Damages* | Average Annual Damages |
|---|---|---|
| Aston Township | 8% | $ 56,200 |
| Brookhaven Borough | 1 | 6,600 |
| Chester Heights Borough | 2 | 14,500 |
| Chester Township | 11 | 77,200 |
| City of Chester | 28 | 205,600 |
| West Chester Borough and West Goshen Township (Goose Creek Basin) | 18 | 133,900 |
| Middletown Township | 17 | 121,500 |
| Upland Borough | 15 | 104,800 |
| Total | 100% | $720,300 |

* Average annual damages were computed for only major damage reaches. Other scattered damages do exist throughout the Basin.

Most damages occur in the lower reaches of Chester Creek. About 54 percent of existing annual damages occur in the City of Chester, Upland Borough and Chester Township. At the Standard Project Flood level 80 percent of the damages would occur in these three communities.

In the lower reaches major damages do not begin to occur until about the 25-year flood level. Damages increase rapidly with increasing flood stages. In the Goose Creek watershed flooding is more frequent. Here about 65 percent of annual damages occur at the 10-year flood level.

About 30 percent of existing annual damages are to residential properties. About 60 percent occur to commercial, industrial and public facilities. About 9 percent are to utilities, highways and bridges and flood emergency costs.

If development of the Basin's upper drainage area continues as predicted, the flooding problems will get worse. Urbanization will result in more frequent and higher flooding with greater damages. The effects of urbanization are significant. By the year 1985 flood damages will increase by 10 percent. In 2035 annual damages will be about $480,000 or 66 percent higher than existing damages. Further comparison of existing and probable future conditions are shown in Table 2.

Flood related needs include:

Immediate need for basin-wide floodwater and flood plain management planning, particularly in the lower Basin at the City of Chester, Upland Borough and Chester Township.

Need for area-wide stormwater planning, to solve the numerous localized drainage problems. The major remaining problem is the Goose Creek Watershed.

Provision for recharging the groundwater table as part of stormwater planning.

Need for a unified and readily available computational procedure for local communities to establish and enforce proper development regulations which require no increase in runoff from development.

EXISTING PROJECTS AND PROGRAMS. There are four levee and floodwall projects in the Basin. The Eyre Park project was constructed by the Corps of Engineers and turned over to the City of Chester in June 1954. This project was overtopped by six to eight feet by the 1971 flood. The Crozer Park Gardens, the Crozer Park, and the Toby Farms projects are earthen levee structures built by local governments. None of these structures are capable of retaining major events. The Crozer Park Gardens and the Toby Farms projects protect residential areas. The Crozer Park project protects recreation facilities.

The Commonwealth of Pennsylvania has enlarged pipes and culverts which carry several small streams through the Borough of Upland. Reduction of flooding caused by inadequate drainage system is expected.

The National Flood Insurance Program is in effect in most communities. Insurance cannot prevent flooding but can reimburse flood victims losses.

STATUS OF EXISTING AND FUTURE PLANS. The Chester Redevelopment Authority is presently redeveloping the Eyre Park area as athletic fields and parking facilities for the Chester High School. The 216 homes in this

TABLE 2
SELECTED
STAGE/DISCHARGE/DAMAGE DATA
CHESTER CREEK BASIN

| Event | Items 1/ 2/ | Levels of Development 1977 | 2020 3/ |
|---|---|---|---|
| General Initiation of Damage | Stage | 34.2 | 34.3 |
| | Discharge | 4,000 | 4,000 |
| | Damage 4/ | $0 | $0 |
| 25-Year | Stage | 41.8 | 44.1 |
| | Discharge | 11,900 | 15,000 |
| | Damage | 2.6M | 5.0M |
| 50-Year | Stage | 44.8 | 46.8 |
| | Discharge | 16,000 | 19,000 |
| | Damage | 6.5M | 14.0M |
| 100-Year | Stage | 47.7 | 49.8 |
| | Discharge | 20,300 | 23,800 |
| | Damage | 16.2M | 21.5M |
| 250-Year | Stage | 50.2 | 52.2 |
| | Discharge | 28,000 | 32,000 |
| | Damage | 21.8M | 25.2M |
| SPF | Stage | 54.0 | 55.5 |
| | Discharge | 35,800 | 40,900 |
| | Damage | 26.9M | 28.1M |
| | Average Annual Damage 5/ | $720,000 | $1,200,000 |

1/ Stages (MSLD) and discharges (cfs) at the USGS gage at Dutton Mill Road.
2/ Inundation damages at the selected level of flooding in sub-reaches 1A through 18F and 51A through 55 as designated.
3/ Limited growth future. Includes affluence and urbanization.
4/ Damages in millions of dollars (M) at the respective stage of flooding. Damages are in January 1978 dollars.
5/ Non-discounted annual damages in January 1978 dollars.

flood prone area were purchased and razed. The Authority also has plans for redevelopment of other flood prone areas within the City of Chester. Land acquisition has begun.

Pennsylvania's "State Water Plan", includes the investigation of flooding problems and solutions throughout Pennsylvania. Pennsylvania has expressed its desire for Corps of Engineers involvement for the Basin. The Corps' work will be incorporated in the State Water Plan.

The Delaware Valley Regional Planning Commission (DVRPC) conducted the "1973 Drainage and Flood Control Work Program" which developed requirements for planning drainage facilities for the major drainage basins in southeastern Pennsylvania. DVRPC has developed an inventory of stormwater drainage systems and has drafted guidelines. These are regional in nature and studies of projects or solutions are not scheduled.

A study was conducted for the Chester School Board for flood protection of the new high school. Investigations of localized flooding problems at Lenni, in Middletown and Aston Township, West Chester Borough and West Goshen Township have been completed. To date no projects have been constructed.

STUDY OBJECTIVES. The objective of this study was to develop a plan for the solution of all existing flooding problems, and a plan for the prevention of new ones. All projects and programs included in the plan need be justified economically and accepted environmentally and socially. Both structural projects and non-structural programs would be considered. Implementation of the plan would be carried out by the appropriate Federal and non-Federal governments. All information developed during the study would be turned over to local authorities for their use.

## FORMULATING A PLAN

Plan Formulation is an orderly process to develop a water management plan that provides for the best uses of water and related land resources to meet the current and projected needs. The formulation process involves identification and development of alternative structural and non-structural plans, evaluation and comparison of these plans against established criteria and selection of an overall plan.

### PLANNING OBJECTIVES

The objective of the Study was to develop a flood control plan to solve flooding problems in the Chester Creek Basin. Water supply and recreational development were also considered, but only as secondary

planning objectives. Study objectives were:

FLOOD CONTROL. Solutions to the flooding problems will be investigated at survey scope level of detail. The responsibility for the detailed planning, design and construction of drainage projects rests with local governments.

WATER SUPPLY. Only flood control plans which also have multipurpose capacity to include water supply will be investigated.

RECREATION. This study will focus on providing recreational facilities and preserving open space areas and natural resources within the context of plans developed for flood control.

## PLAN FORMULATION

Formulation and evaluation of alternatives were carried out in four cycles. The detail of the investigations increased with each succeeding cycle. The initial cycle was the identification and preliminary consideration of all possible structural and non-structural measures for eliminating or reducing flood-related problems. All measures were looked at to see if they could be modified to also satisfy water supply and recreation needs. Investigations were conducted at a low level of detail. Measures which were technically infeasible or obviously too costly were eliminated from further consideration.

In the second cycle physical and economic performance and potential impacts of the plans were evaluated. Physical performance for flood control was measured by decreases in discharges, lowering of flood stages and increases in level of protection. For water supply, measurement of performance was the ability to meet demands in a more efficient manner than other future sources. Recreation performance was determined by the ability to satisfy the established recreation needs.

Economic performance was measured by the amount of benefits to be derived and the ability to achieve the benefits for an equal or lower cost. A minimum benefit to cost ratio (BCR) of 0.8 was required. However, this had to be supported with the prospect that more detailed investigations would result in a BCR greater than 1.0.

The primary purpose of the impact assessment was to identify major or critical impacts. Cycle 2 studies were conducted for fourty-seven plans. Many variations of these fourty-seven plans were eliminated in prior studies. Only twelve of these plans indicated potential and were recommended for further consideration. No plans were eliminated at this point solely because of adverse socio-economic, environmental or regional impacts.

Cycle 3 was an institutional and implementation analysis. All alternatives which were investigated in Cycle 2 were coordinated with local, county and state officials and later presented to the public. A statement as to fiscal capability and intent to provide local support were sought for the twelve plans which were recommended for further study. Only two plans received sponsorship.

The fourth cycle consisted of more detailed technical and economic investigations of the two plans supported by local interests. More detailed impact assessments were not conducted since neither plan was found to be economically justified.

## FORMULATION AND EVALUATION CRITERIA

All plans were formulated and evaluated on the basis of technical, economic, environmental, socio-economic and implementation criteria. This includes the criteria specified in the Water Resources Council's Principles and Standards, the National Environmental Policy Act of 1969, and related Corps regulations and guidelines.

Specific criteria were established for application to all alternatives being considered. These criteria are summarized as:

High levels of protection should be provided due to the urban nature of the area and the threat to life, health and safety.

Each plan must function without causing adverse effect in other areas.

The benefits expected to be realized by any plan must be greater than the cost of the plan.

Each plan should promote the development of pleasing aesthetics and other desirable environmental effects and avoid detrimental environmental effects.

Each plan must be acceptable by the affected communities.

Existing flood plain zoning laws and ordinances were followed. No further development will take place in the 100-year flood plain unless it is either above the 100-year flood elevation or flood proofed to that elevation. No further inundation damages would result from future development in the flood plain.

All of the plans considered were evaluated based on a discount rate of 6-1/8% (and 8 and 10 percent for some) and a project life of 50 years (and 100 years for some). The study year was 1975, and year a plan would be operational was 1980. All decisions whether to recommend plans for further consideration and whether to provide local sponsorship were based on these economic criteria.

Those two plans which were considered further were analyzed at January 1978 prices; 6-5/8 percent interest; 1977 study year; plan operative by 1985; and an economic life of 50 years.

## POSSIBLE SOLUTIONS

Many alternative plans were investigated. Due to the urban nature of the area and the high probability of loss of life and large damages, high levels of protection were required. Plans which would allow the area to still be flooded or which would only reduce damages by a small amount were not investigated at the same level of detail as others. These types of plans were considered to supplement the preventive measures or as a substitute if preventive alternatives were not found feasible or acceptable.

All of the measures which were considered are listed below. The letters (P) and (R) indicate that the measure was considered to be preventive or reductive, respectively.

STRUCTURAL

- Bridge Modifications and Replacements (P)
- Bypass Channels (P)
- Channel Modifications (deepening, widening and realignments of existing channels) (P)
- Drainage System Improvements (P)
- Dry Detention Reservoirs (P)
- Levees and Floodwalls (P)
- Natural Channel Storage (natural impoundments) (P)
- Permanent Pool Reservoirs (multi-purpose) (P)
- Tidal Dams (P)

NON-STRUCTURAL

- Contingency Flood Proofing (P)
- Flood Forecasting (R)
- Flood Insurance (R)
- Regulatory Measures, Flood Plain Zoning and Floodway Ordinances (R)
- Flood Preparedness Planning (R)
- Flood Warning (R)
- Land Development Regulations in Upland Areas (R)
- Tax Adjustments or Acquisition of Development Rights (R)
- Permanent Evacuation or Relocation (P)
- Pervious Paving (R)
- Temporary Evacuation (R)

MINOR DAMAGE AREAS. No local protection plans were considered for minor damage areas where potential benefits obviously could not justify any project.

NATURAL CHANNEL STORAGE. Two plans were considered. One plan considered insuring natural storage by acquisition in fee or acquisition of only specified development rights of storage sites. Another plan considered increasing the efficiency of storage sites with a series of in-stream devices such as weirs. Neither concept could be economically justified solely on reducing flood damages.

TIDAL DAMS. The area affected by high tides is small and damages low. Increased stages of fluvial flooding due to above normal tides dissipates within the first hundred feet above the mouth of the Creek. Benefits accrued within the first few sub-reaches could not justify expenditures for a tidal dam.

REGULATORY MEASURES, FLOOD PLAIN ZONING AND FLOODWAY ORDINANCES. A review was made of regulatory measures, zoning and ordinances being adopted to meet National Flood Insurance Program requirements. More stringent or expansive requirements would not eliminate or reduce the existing flooding problems, but would eliminate or reduce increases in future damages. Implementation of stronger requirements is a local responsibility.

LAND DEVELOPMENT REGULATIONS IN UPLAND AREAS AND PERVIOUS PAVING. These measures retard stormwater runoff from stream flood flows. While they reduce future increases in flooding they do not solve existing problems. Their maximum effectiveness would be limited to eliminating future problems which will occur due to future urbanization. Implementation of these measures is a local responsibility.

## PLANS CONSIDERED

FLOOD INSURANCE. This plan promotes the National Flood Insurance Program and seeks 100% participation. Flood insurance offers property owners a means of avoiding catastrophic losses due to floods. Although it provides no physical improvements, the Program requires implementation of flood plain zoning regulations. These regulations, when properly enforced, guide the use of the flood plain so that future damages are kept at a minimum.

Most homes, multi-unit residences, commercial buildings, and small industries in the Basin can be adequately covered by the program. However, the larger industries in the Basin would be underinsured. Flood insurance does not eliminate the cost of cleanup after a flood. Because the flood hazard remains, the threat to public safety and loss of life is still present. The cost of the insurance premium is the second most effective method of calling attention to the flood risk. The first is a flood itself. Presumably the cost will encourage the modification of use and/or eventually removal of buildings from hazardous areas. Conversely, the availability of insurance and avoidance of catastrophic loss may encourage continued occupancy in the flood plain in some cases

From a national perspective flood insurance is justified on the basis of future land use regulations in flood plain and social benefits. Promotion of the National Flood Insurance Program is a local responsibility.

PERMANENT FLOOD PLAIN EVACUATION. Evacuation removes and relocates people and damageable property from the flood hazard area. Evacuation was considered for all major damage areas using a sampling technique. More comprehensive evacuation plans were investigated for two locations in the City of Chester; one in Central Business District and the other in a residential area known as Crozer Park Gardens. Comprehensive plans were evaluated to see if increased efficiency could result in economics of scale; increased stream capacity; or better use of lands for major recreation or redevelopment uses.

Evacuation cannot be economically justified solely for flood control. It also has major adverse social and economic impacts. Evacuation can aid in developing a "greenbelt" along the Chester Creek. Opportunity and facilities for hiking, bicycling, picnicking, athletic facilities, municipal parking and other compatible uses such as boat launching were considered. Benefits for these purposes would be greater than the flood control benefits. The flood control benefits and costs are summarized below.

| Plans | E-1 Sample Analysis* | E-2 City of Chester CBD | E-3 Crozer Park Gardens |
|---|---|---|---|
| Project Costs | $18,100 to $506,400 | $847,000 | $2,124,000 |
| Average Annual Benefits | $55 to $8,100 | $10,600 | $47,900 |
| Average Annual Costs | $1,200 to $32,700 | $55,000 | $137,600 |
| Benefit/Cost Ratio | 0.03 to 0.44 | 0.19 | 0.35 |
| Other Considerations | Major adverse social and economic impacts | | |

* Range of 11 samples investigated.

FLOOD PROOFING. Flood proofing protects a property by sealing the structure. Sample buildings were selected throughout the Basin for individual analysis. The samples were chosen in order to represent different types of construction and uses.

A building should not be sealed above a level which the structure can withstand. Sample structures were reviewed for theoretical

structural capacity based on the type of construction. It was found that about 40, 75, and 100 percent of the residential, commercial and industrial, and public buildings, respectively, are able to withstand the floodwater forces and stresses resulting from flood proofing to the 100 year level.

Of these, 100, 55, and 65 percent, respectively, are found to be economically justified. Floodproofing results in 50, 70, and 90 percent reductions in total average annual damages for the sample buildings, respectively. Applied basin-wide, the annual reduction in damages would be 20, 30 and 20 percent for each category, respectively. Economically justified floodproofing measures could be provided for about 40% of all residential buildings, 40% of commercial and industrial buildings, and 65% of all public buildings located in the flood plain.

Flood proofing may economically provide high levels of protection to some structures. However, the local interests did not provide sponsorship and it will not be considered further. Delaware County is interested in pursuing this concept on its own.

FLOOD FORECASTING, WARNING, AND PREPAREDNESS PLANNING. This plan does not eliminate but can reduce flood damages. It has the potential to prevent the loss of life. The existing forecasting and warning system has been improved as part of the continuing program of cooperation between the National Weather Service (NWS) and the Chester County Civil Defense since the 1971 flood. The loss of eight lives and damages to more than 200 motor vehicles in the 1971 flood attests to the fact that either a warning was not sufficient or a poor response was obtained at that time. The improvements made since 1971 include the installation of a flash flood warning alarm consisting of a sensor located off Old Forge Road near Glen Mills and an alarm located at the Media Court House. This system was installed in 1973. In addition, there has been improvement in communications between the County Civil Defense and NWS during storm periods. Although these improvements have not yet been tested by a major flood, it is felt that the existing arrangements are still not adequate.

It is recommended that the existing preparedness plan be improved to provide a better forecasting system consisting of a rainfall observer network in upstream areas and additional staff and sensor gages of critical locations along Chester Creek, an improved warning system and an emergency plan of action.

This plan would consist of NWS flood forecasts, a rainfall observer network in upstream areas, sensor gages along Chester Creek, a warning system and an emergency plan of action.

This plan can reduce flood problems; is economically justified; and has only minor adverse impacts. Local interests are interested in pursuring this concept on their own. A summary of this plan's economics follows.

| | |
|---|---|
| Project Cost | - $86,700 |
| Average Annual Costs | - $20,800 |
| Average Annual Benefits | - $81,900 |
| Damage Reduction (%) | - 10% |
| Benefit/Cost Ratio | - 3.9 |

RESERVOIR STORAGE. Multi-purpose potential, including flood control, water supply and recreation was considered. It became immediately obvious that, water supply could only be developed at the expense of flood control because of the following factors: the size of the Chester Creek Basin; limited physical relief for impoundment; and unavailability of many impoundment sites because of the degree of existing urban development.

Since floodwater and flood plain management is the primary purpose of this study, water supply potential was assumed to be a secondary consideration. Further evaluation of which purpose has the dominate need, would require more detailed investigations. Because of stated constraints to developing reservoirs, single purpose dry reservoir concepts were therefore emphasized. Recreation potential was estimated only for the economically attractive dry reservoirs.

Twenty-one potential storage sites were identified during Cycle 1- Initial screening was conducted during the field reconnaissance. Sites were eliminated because of constraints to project development which were identified in the field. Five of the twenty-one sites were eliminated. The remaining sixteen are shown on Plate 8.

Three additional screenings were conducted during Cycle 2. The first was based on the hydrologic effects of the reservoirs. Reservoirs 11, 12 and 15 through 21 individually have little or no effect and, therefore, were screened out from further consideration. The second screening was based on approximate project costs and the damages reduced. As a result of this, reservoirs 2, 7, 9 and 15 were eliminated. Only reservoir plan R6, R10 and R13 were investigated at the complete Cycle 2 level of detail. However, these were also eliminated on the third and final screening. All three can provide some protection; but, they can not be economically justified as flood control projects and have major adverse environmental effects. A summary of the flood control benefits and costs follows:

| Plans | R-6 West Branch Chester Creek | R-10 West Branch Chester Creek | R-13 Main Stem Chester Creek |
|---|---|---|---|
| Project Costs | $3,000,000 | $8,090,000 | $14,780,000 |
| Average Annual Costs | $ 224,000 | $ 552,000 | $ 990,000 |
| Average Annual Benefits | $ 195,000 | $ 419,000 | $ 188,000 |
| Percent Damage Reduction | 28 | 60 | 27 |
| Benefit/Cost Ratio | 0.87 | 0.76 | 0.19 |

LOCAL IMPROVEMENT PLANS. All possible types of local structural and non-structural solutions were considered at each major damage area. The plans which were selected as the best plans for each area are listed below and their general location shown on Plate 9. These plans were eliminated from further consideration in Cycles 2 and 3. They were eliminated due to: not being economically justified (UNJUSTIFIED); not a Federal but a local responsibility (LOCAL); or did not receive local sponsorship (NO SUPPORT). A summary of each plan is presented in the following paragraphs.

| ALPHA-NUMERIC | ALTERNATIVE PLAN IDENTIFICATION | LOCATION | REASON ELIMINATED |
|---|---|---|---|
| L1 | Levees & Floodwalls | City of Chester | Unjustified |
| L2 | Levees & Floodwalls | City of Chester Schools | Unjustified |
| L3 | Levees, Floodwalls & Channel Realignment | City of Chester (Schools & YMCA) | Unjustified |
| L4 | Levees & Floodwalls | Crozer Park Gardens | Unjustified |
| L5 | Bridge Modification | City of Chester & Borough of Upland | Unjustified |
| L6A, L6B L6C, L6D | Bridge Modification | City of Chester | Local |
| L6E | Channel Clearance | City of Chester | Local |
| L6F | Channel Clearance | City of Chester & Borough of Upland | Local |
| L7A, L7B | Channel Excavation | City of Chester, Upland Boro, Chester Twp, Brookhaven Boro, Aston Twp | Unjustified |
| L7C, L7D | Channel Excavation | City of Chester, Upland Boro, Chester Twp | Unjustified |
| L8A, L8B | Levee | Chester Twp (Toby Farms) | No Support |
| L9 | Levee | Aston Twp | Unjustified |
| L10A, L10B | Levees, Floodwalls, & Bridge Modifications | Aston Twp & Middletown Twp (Lenni) | No Support |
| L11 | Levees, Floodwalls, Bridge & Channel Modifications | Aston Twp, Middletown Twp & Chester Heights Boro (Aston Mills) | Unjustified |

PLAN L1 consists of 1750 feet of earth levee and 2050 feet of concrete floodwall from 3rd Street to the Penn Central Railroad Bridge in the City of Chester. The structures would be from 5 to 15 feet high.

Project Cost
$1,563,000

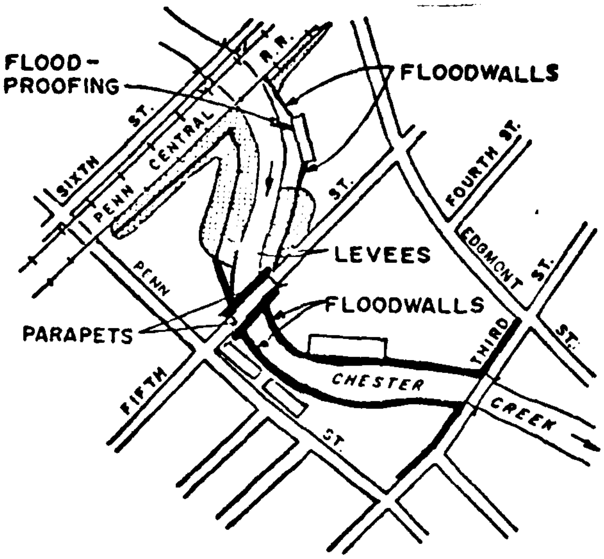
Annual Average Benefits
$16,800

Benefit to Cost Ratio
0.17

Reduction in Damages
50%

Level of Protection
100-Year Flood

Other Considerations
Adverse aesthetic and social effects




PLAN L2 protects the Chester High School and the Christopher Columbus Elementary School in the City of Chester. It includes 2400 feet of earth levee and 150 feet of concrete floodwall. The structures would be up to 18 feet high and extend from 9th Street to Interstate 95.

Project Cost
$641,000

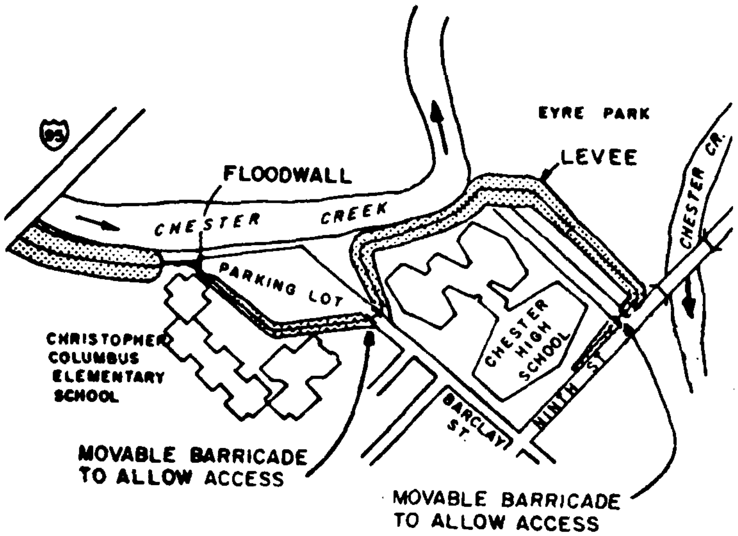
Average Annual Benefits
$16,600

Benefit to Cost Ratio
0.40

Reduction in Damages
53%

Level of Protection
100-Year Flood

Other Consideration
Adverse aesthetic and social effects



PLAN L3 extends from 6th Street up to Interstate 95 in the City of Chester. It includes 4500 feet of levee, 1900 feet of concrete floodwall, and 1900 feet of channel realignment. The structures would be up to 18 feet high. The new channel would be 150 feet wide.

Project Cost
$4,374,000

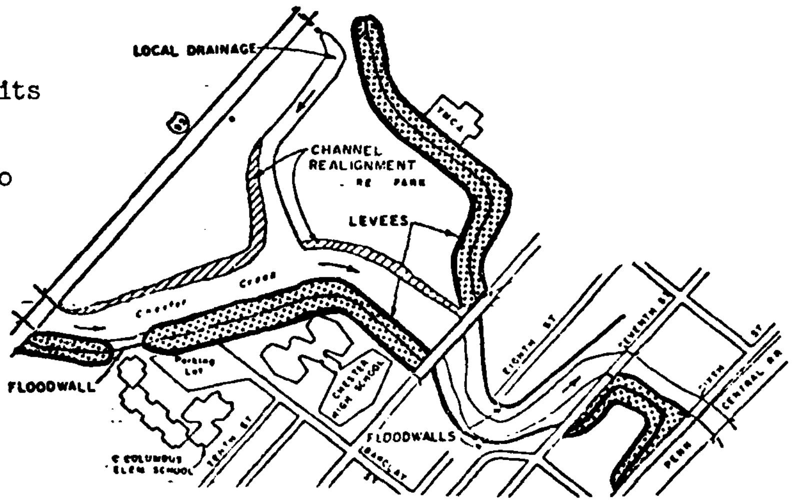
Average Annual Benefits
$56,600

Benefit to Cost Ratio
0.20

Reduction in Damages
52%

Level of Protection
100-Year Flood

Other Considerations
Adverse aesthetic, environmental and social effects




PLAN L4 protects 80 homes in the Crozer Park Gardens section of the City of Chester. About 750 feet of earth levee and 650 feet of concrete floodwall extend from the B&O Railroad Bridge to Kerlin Street. A portion of Kerlin Street would be raised. The structures would average 20 to 21 feet in height.

Project Cost
$1,924,000

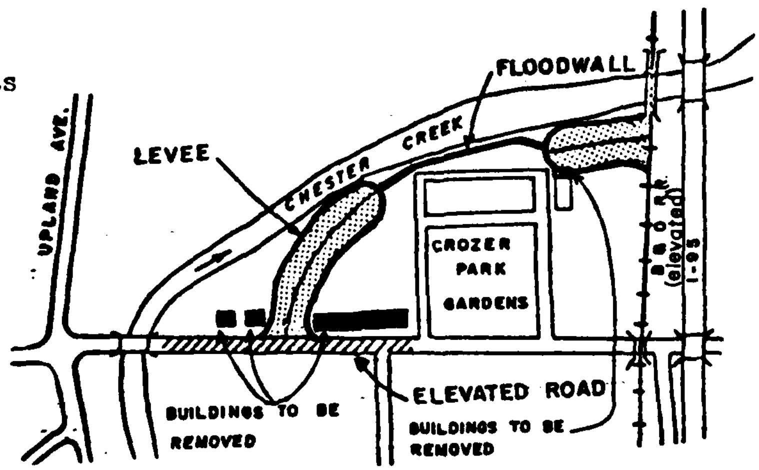
Average Annual Benefits
$ 38,000

Benefit to Cost Ratio
0.31

Reduction in Damages
71%

Level of Protection
100-Year Flood

Other Considerations
Adverse aesthetic and social effects



PLAN L5 extends from the B&O Railroad Bridge in the City of Chester up to Upland Road in the Borough of Upland. It includes 3800 feet of earth levee, 2600 feet of concrete floodwall, and 3000 feet of channel realignment. The structures would be between 6 to 23 feet high and the new channel 170 feet wide.

Project Cost
$7,636,000

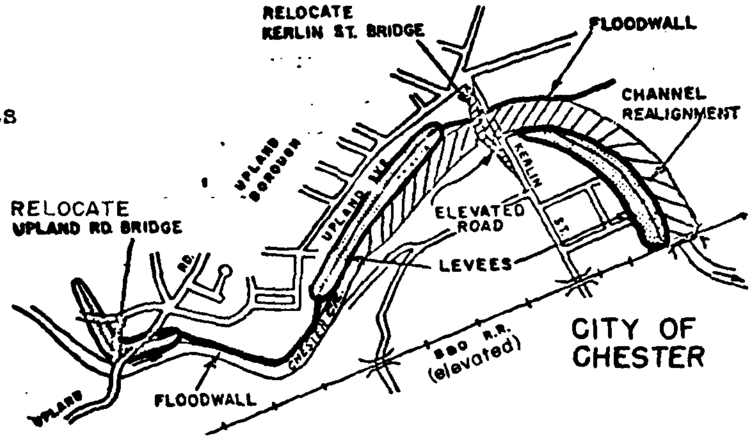
Average Annual Benefits
$110,100

Benefit to Cost Ratio
0.22

Reduction in Damages
64%

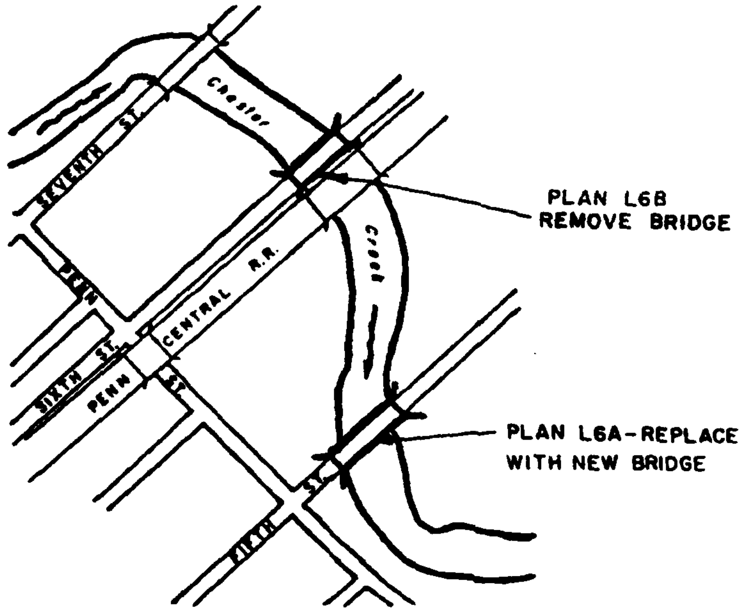
Level of Protection
100-Year Flood

Other Considerations
Adverse aesthetic, environmental and social effects



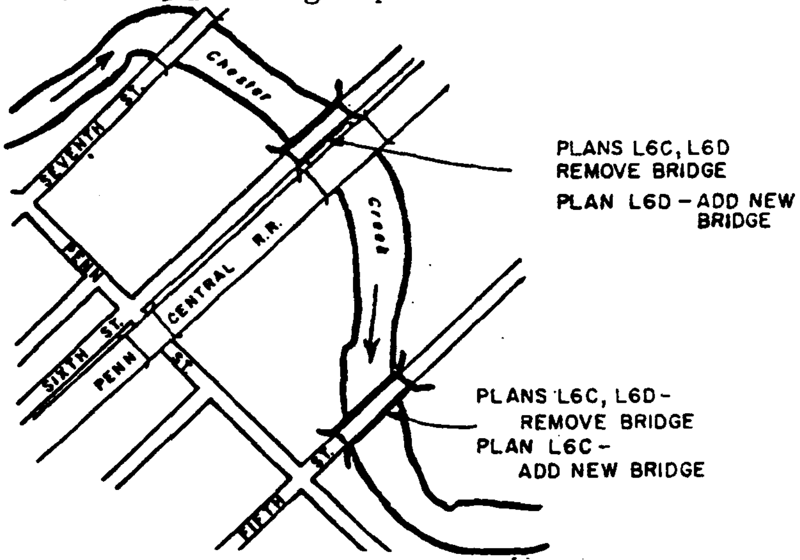

PLANS L6A & L6B consist of modifications to two bridges in the City of Chester. Projects would reduce 2 to 18 foot flood stages from 1 to 3-1/2 feet from 5th Street (L6A) or 6th Street (L6B) to Chester Township. The new bridge (L6A) would be a 105 foot single span.

Project Cost
L6A $447,000
L6B $56,000
Average Annual Benefits
L6A $77,000
L6B $22,500
Benefit to Cost Ratio
L6A 2.7
L6B 6.3
Reduction in Damages
L6A 19%
L6B 5%
Level of Protection
Varies
Other Considerations
L6B would affect traffic patterns



PLANS L6C & L6D consist of various modifications to the 5th, 6th and 7th Street Bridges in the City of Chester. The projects would reduce a 2 to 18 foot flood stage by up to 3-1/2 feet from 5th Street to Chester Township. New bridges would be 105 foot single spans.

Project Cost
L6C $503,000
L6D $484,000
Average Annual Benefits
L6C $93,400
L6D $88,700
Benefit to Cost Ratio
L6C 2.9
L6D 2.8
Reduction in Damages
L6C 23%
L6D 22%
Level of Protection
Varies
Other Considerations
Affect traffic patterns




PLAN L6E consists of initial and periodic removal of sediment material under the 5th and 6th Street Bridges in the City of Chester. The project would reduce 2 to 18 foot flood stages by 1 foot from 5th Street to Chester Township. Maintenance would be required every few years.

Project Cost
$16,000

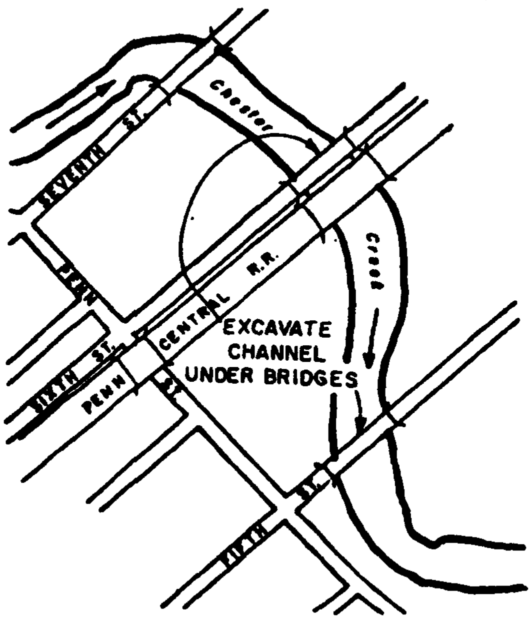
Average Annual Benefits
$40,500

Benefit to Cost Ratio
13.5

Reduction in Damages
10%

Level of Protection
Varies

Other Considerations
Adverse environmental effect to the stream



PLAN L6F consists of initial and periodic removal of sediment material from 650 feet of stream channel at the Kerlin Street Bridge between the City of Chester and the Borough of Upland. The project would reduce 2 to 18 foot flood stages by 1 foot from the project site to Chester Township. Maintenance would be required every few years.

Project Cost
$35,000

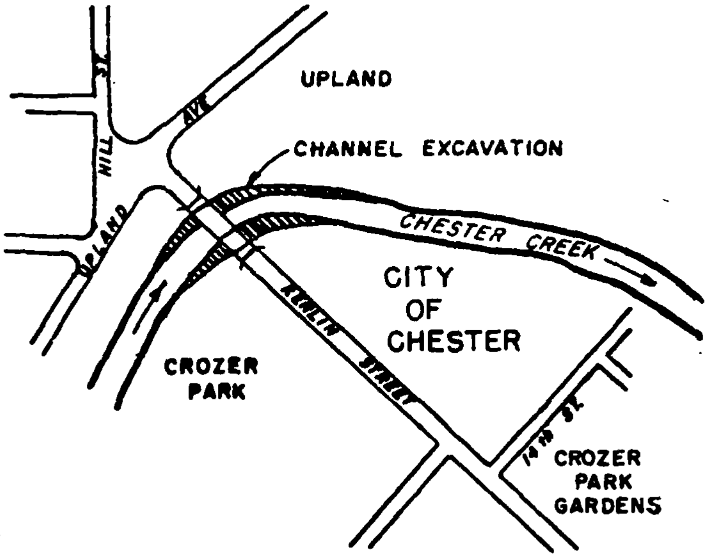
Average Annual Benefits
$15,500

Benefit to Cost Ratio
4.1

Reduction in Damages
7%

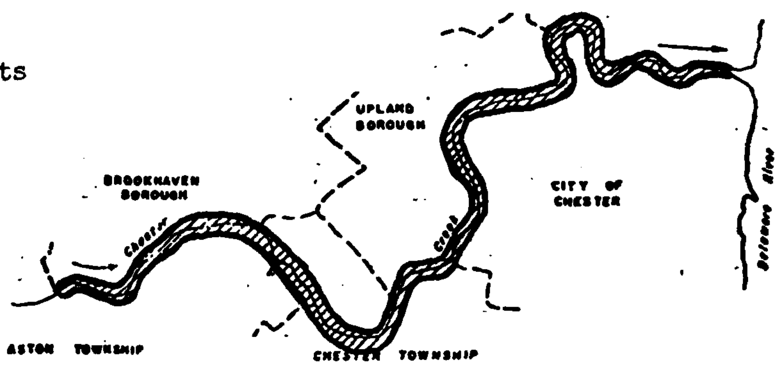
Level of Protection
Varies

Other Considerations
Adverse environmental effects to the stream



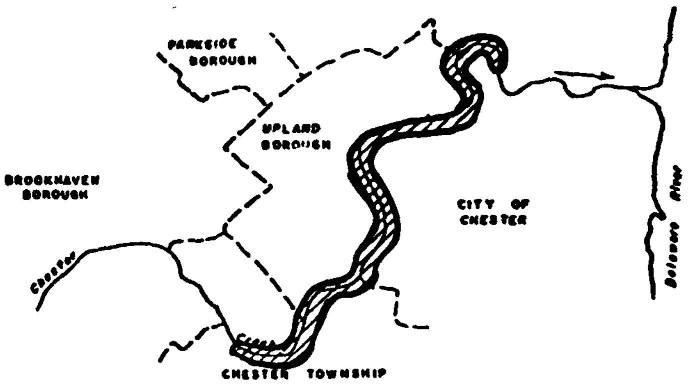

PLANS L7A & L7B involve dredging 27,600 feet of Chester Creek from the Delaware River to Middletown Township. The stream would be deepened by 2 feet (L7A) or 4 feet (L7B). The projects would reduce 2 to 18 foot flood stages by 1 to 2 feet. Maintenance would be required every few years.

Project Cost
L7A $1,588,000
L7B $2,627,000
Average Annual Benefits
L7A $95,200
L7B $132,100
Benefit to Cost Ratio
L7A 0.87
L7B 0.75
Reduction in Damages
L7A 20%
L7B 28%
Level of Protection
Varies
Other Considerations
Adverse environmental effects to the stream



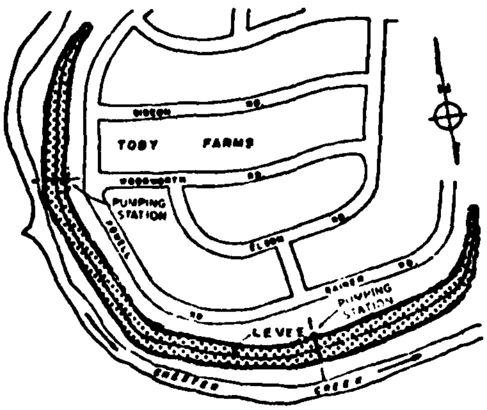
PLANS L7C & L7D involve dredging 13,500 feet of Chester Creek from 9th Street in the City of Chester to Chester Township. The stream would be deepened 2 feet (L7C) or 4 feet (L7D). The projects would reduce 2 to 18 foot flood stages by 1 to 2 feet. Maintenance would be required every few years.

Project Cost
  L7C $902,000
  L7D $1,517,000
Average Annual Benefits
  L7C $42,700
  L7D $63,800
Benefit to Cost Ratio
  L7C 0.66
  L7D 0.61
Reduction in Damages
  L7C 24%
  L7D 36%
Level of Protection
  Varies
Other Considerations
  Adverse environmental effects to the stream



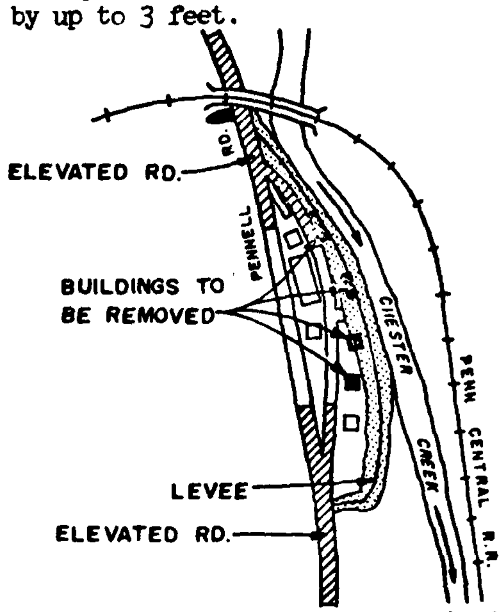

PLANS L8A & L8B provide protection for 148 homes (L8A) or 258 (L8B) in the Toby Farms section of Chester Township with 2800 to 2900 feet of levee. The levees would be up to 15 feet high for L8A and up to 22 feet high for L8B.

Project Costs
  L8A $844,000
  L8B $1,173,000
Average Annual Benefits
  L8A $114,900
  L8B $135,900
Benefit to Cost Ratio
  L8A 1.5
  L8B 1.3
Reduction in Damages
  L8A 71%
  L8B 89%
Level of Protection
  L8A 100-Year Flood
  L8B SPF*
Other Considerations
  Adverse aesthetic and social effects




* The Standard Project Flood (SPF) is the flood resulting from the most severe combination of hydrometeorological conditions reasonably characteristic of the geographical area of concern, excluding extremely rare combinations.

PLAN L9 provides protection for the Centennial Home Center (Ahren's Lumber Co.) section of Aston Township. It includes 1350 feet of earth levee and raising Pennell Road by up to 3 feet.




Project Cost
  $579,000

Average Annual Benefits
  $17,000

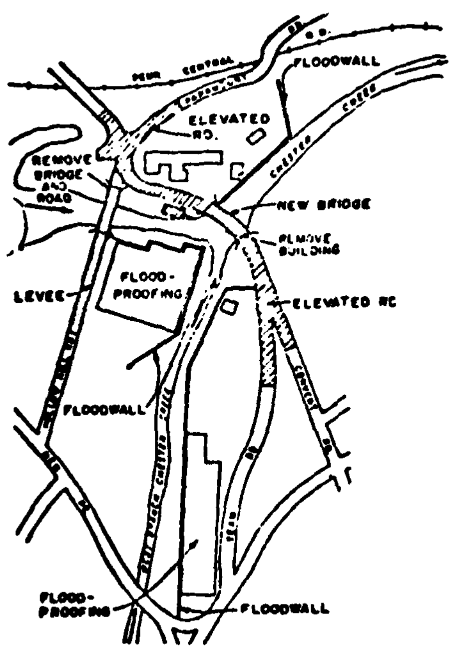
Benefit to Cost Ratio
  0.47

Reduction in Damages
  60%

Level of Protection
  100 Year Flood

Other Considerations
  Protects basically a single property

PLANS L10A & L10B provide protection for four businesses in Aston and Middletown Townships. It includes 370 feet of earth levee, 2250 feet of concrete floodwalls, raising roads, modification to bridges, and lining portions of the stream with riprap (rock). Floodwalls would be 10 to 13 feet high for L10A and 14 to 17 feet high for L10B.




Project Cost
  L10A $1,541,000
  L10B $1,958,000
Average Annual Benefits
  L10A $133,600
  L10B $136,500
Benefit to Cost Ratio
  L10A 1.3
  L10B 1.02
Reduction in Damages
  L10A 89%
  L10B 91%
Level of Protection
  L10A 100-Year Flood
  L10B SPF
Other Considerations
  Affect traffic patterns, adverse aesthetic and social effects

PLAN L11 provides protection for 4 businesses and 1 home in the Aston Mills area in Aston and Middletown Townships and Chester Heights Borough. It consists of 770 feet of earth levee, 430 feet of concrete floodwalls, and a new Lenni Road Bridge. Levees would be about 9 feet high and floodwalls 14 feet high.

Project Costs
$931,000

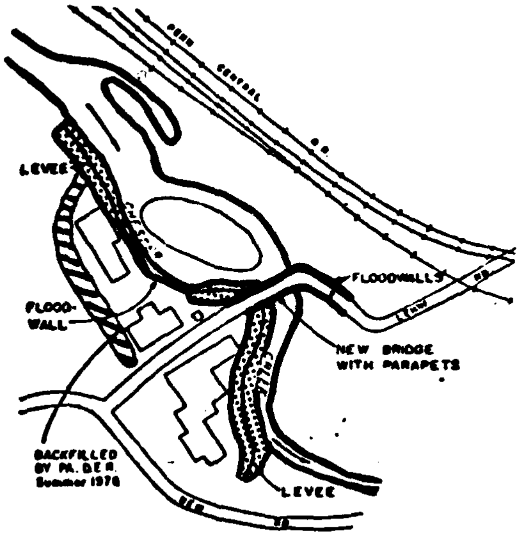
Average Annual Benefits
$19,800

Benefit to Cost Ratio
0.33

Reduction in Damages
90%

Level of Protection
100-Year Flood

Other Considerations
Adverse aesthetic and social effects




<u>FLOODWATER/STORM DRAINAGE ALTERNATIVE CONSIDERED</u>. Two areas in the Chester Creek Basin have experienced flooding which was not obviously out-of-bank type flooding. Their flooding problem is a combination of both out-of-bank and stormwater drainage type flooding. It was therefore necessary to determine the actual nature of flooding. This was done not only to physically define the flooding problem but also to establish whether Federal consideration is warranted, or whether it was totally a local responsibility. One area includes Lukens, Maris, and Crozer Runs in the Borough of Upland. The other area is the Goose Creek Watershed within the Borough of West Chester and West Goshen Township.

Lukens, Maris, and Crozer Runs were investigated at a reconnaissance level by the Corps of Engineers in 1966*. The report identified that a 25-year stormwater sewer system would solve most of the flooding problems in these three Runs. At that time Federal participation could not be recommended since it was determined the plan was designed to prevent damages caused by runoff originating within the community. Subsequent to this report, the Commonwealth of Pennsylvania conducted a study on this area in 1968-1969,** A project with a 25-year frequency storm

* Reconnaissance Report; Flood Problems at Upland, Delaware County; Philadelphia District, U.S. Army Corps of Engineers; April 1966.
** Borough of Upland, Delaware County, Commonwealth of Pennsylvania. Flood Control Study; Justin and Courtney, Consultant Engineers for the Pennsylvania Department of Environmental Research.

level of design has been constructed. A reanalysis confirmed that most of the fluvial flooding along these three Runs will be solved with the State's stormwater sewer project. Residual damages would not be sufficient to justify any additional improvements. However, flooding can still be caused by floodwaters backing up these three Runs from the Chester Creek. Solution of this backwater flooding was included in study for the Borough of Upland's flood problems.

The Goose Creek study area is a flat lowland area. A major portion of its recurrent flooding problems are caused by overland or drainage type flooding. Two previous studies identified a 50-year level of design to relieve most of the flooding.* The proposed plans consisted primarily of storm sewer components with bridge or road culvert modifications. These findings were confirmed by the Chester Creek Basin Study.

The existing stormwater sewer is basically a 2-year system. Both West Chester and West Goshen officials indicate that a 50-year system is beyond the resources of their communities. These communities will increase the capacities as part of their normal maintenance and facilities upgrading program. This upgrading will be far below the recommended 50-year design level; therefore, plans were considered under this study for possible Corps of Engineers participation.

The plans listed below were considered in Cycle 2. However, all were eliminated from further study because they were not economically justified. A summary of each plan is presented in the following paragraphs.

Plan L12 - CHANNEL MODIFICATION

Plan L13 - BOLMAR STREET BYPASS

Plan L14 - SOUTH FRANKLIN STREET BYPASS

* Drainage Study of Goose Creek and West Washington Street area, West Chester Borough, Chester County, Pennsylvania; G.D. Houtman & Son, Media, Pennsylvania; September 13, 1972. Storm Drainage Study, East Branch Goose Creek Drainage Basin, prepared for Industrial Commercial Study Group; Smith, Chatman-Royce Associates, Malvern, Pennsylvania; October 23, 1973.

PLAN L12 involves deepening and widening the Main Stem Goose Creek in West Chester Borough and West Goshen Township. The project would extend 3000 feet from above U.S. Route 322 to right below South Franklin Street. It would require one bridge modification.

Project Cost
$158,000

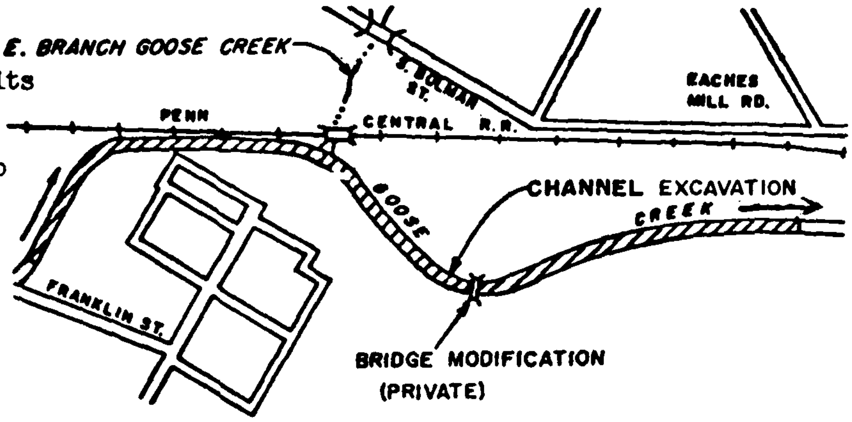
Average Annual Benefits
$5,500

Benefit to Cost Ratio
0.54

Reduction in Damages
37%

Level of Protection
50-Year Flood

Other Considerations
Adverse environmental effects to stream




PLAN L13 involves stormwater bypass and channel excavation in West Chester Borough and West Goshen Township. It includes 4900 feet of pipeline along Polmar Street from the Main Stem to East Branch Goose Creek; widening and deepening 3000 feet of Goose Creek; and one bridge modification.

Project Cost
$2,263,000

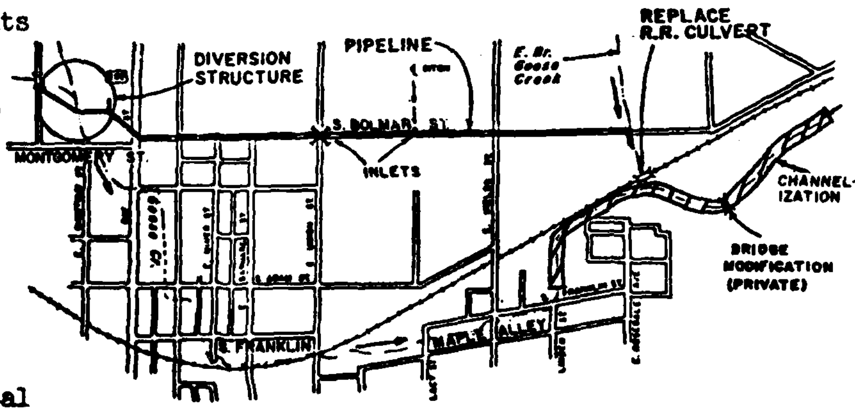
Average Annual Benefits
$117,200

Benefit to Cost Ratio
0.80

Reduction in Damages
87%

Level of Protection
50-Year Flood

Other Considerations
Adverse environmental effects to stream



PLAN L14 involves stormwater bypass and channel excavation in West Chester Borough and West Goshen Township. It includes 3300 feet of pipeline and 700 feet of new channel for a diversion from Goose Creek along Franklin Street to East Branch Goose Creek; new storm water inlets and 2870 feet of pipeline along South Bolmar Street; 3000 feet of channel widening downstream of South Franklin Street; and one bridge modification.

Project Cost
$2,247,000

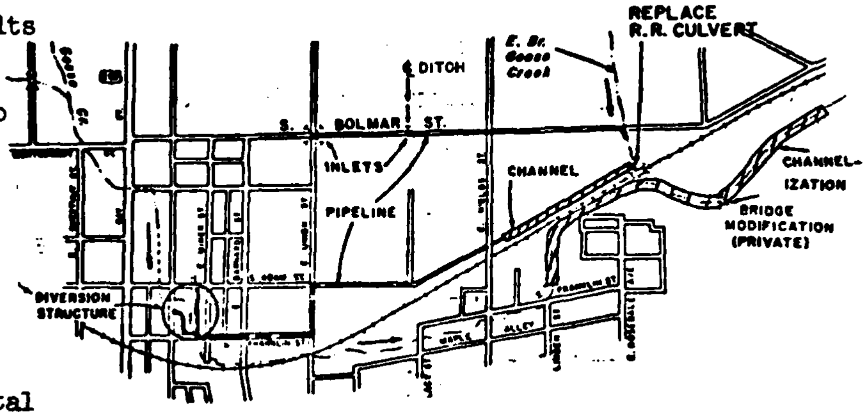
Average Annual Benefits
$115,400

Benefit to Cost Ratio
0.80

Reduction in Damages
88%

Level of Protection
50-Year Flood

Other Considerations
Adverse environmental effects to stream




COMBINATION PLANS. In order to determine if greater hydrologic, hydraulic, and economic efficiency could be derived through combinations of plans, systems analyses were performed on those combinations with a potential for increased efficiency.

A description of the combinations which were considered is presented in Table 17

Only the S3 combinations include a concept different than those considered in the individual plans. S3A through S3D include a modified alignment of the Chester Creek. The S3 plans vary due to differences in channel alignment and bridge replacements. After the results of the previous systems were evaluated, further refinement was made to achieve greater efficiency. These three systems (S4A through S4C) were therefore analyzed.

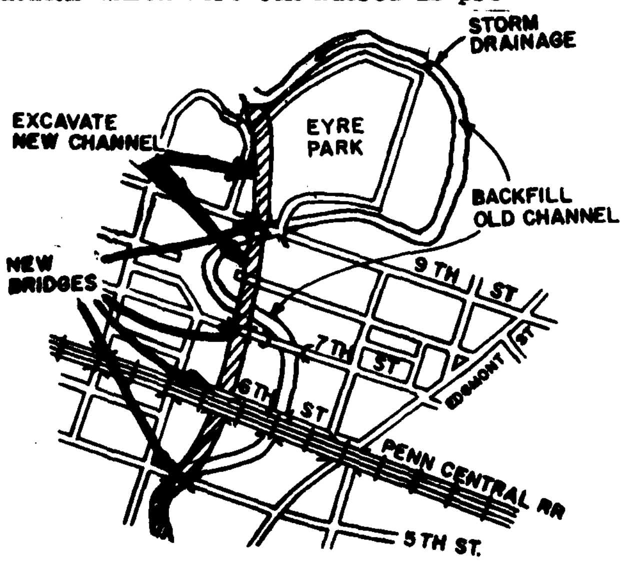


TABLE 3
SUMMARY DESCRIPTIONS
COMBINATION PLANS

| System | Combinations of Basic Alternatives | Changes to Basic Alternatives | General Description |
|---|---|---|---|
| S1A | R6, R10 | None | Combination of two reservoirs. |
| S1B | R6, R13 | None | Combination of two reservoirs. |
| S1C | R10, R13 | None | Combination of two reservoirs. |
| S1D | R6, R10, R13 | None | Combination of three reservoirs. |
| S2A | R6, R10 | New 9th Street Bridge | Combination of two reservoirs; a new bridge at 9th Street. |
| S2B | R6, R10, L6C, L7B | New 7th & 9th Street Bridges | Combination of two reservoirs; removal of 6th Street Bridge; New 5th, 7th & 9th Street Bridge 4-foot channel modification from the confluence with the Delaware River to Dutton Mill Road. |
| S3A 1/ | | | New Channel Alignment; 6th Street out at Creek; new 5th, 7th & 9th Street Bridges . |
| S3B | S3A, L7B | 4-foot channel modification | New channel alignment; 6th Street out at Creek; new 5th, 7th & 9th Street Bridges ; 4-foot channel modification. |
| S3C | | Alternate channel alignment between 3rd & 5th Street Bridges | New 5th, 7th & 9th Street Bridges 6th Street out at Creek*; new channel alignment with alternate alignment between 3rd & 5th Streets |
| S3D | S3C, L7B | 4-foot channel modification | New 5th, 7th & 9th Street Bridges 6th Street out at Creek ; new channel alignment with alternate alignment between 3rd & 5th Streets ; 4-foot channel modification. |
| S4A | R10, S3A | None | One reservoir; new channel alignment; remove 5th & 9th Stree Bridges; new 5th, 7th & 9th Stree Bridges. |
| S4B | R10, L6C | New 7th & 9th Street Bridges | One reservoir; remove 6th Street Bridge; new 5th, 7th & 9th Street Bridges . |
| S4C | R10, L6C, L7B | New 7th & 9th Street Bridges | One reservoir; remove 6th Street Bridge; new 5th, 7th and 9th Street Bridges ; 4-foot channel modification. |

1/ Recommended for further consideration.

A summary of findings for each system considered is presented in Table 4. Reasons why these plans were eliminated from further consideration are noted.

## INSTITUTIONAL STUDIES

As a result of technical, economic and socio-environmental analyses and investigations, twelve plans were recommended for further consideration. Information on these plans were presented to State, County and local officials, special interest groups, and the general public. Meetings were held with each community where projects might be located as well as with State, County, and Congressional representatives.

Chester Heights Borough and Concord Township passed resolutions opposing any plans which included dry reservoirs in their communities. Chester Township passed a resolution not supporting the levee plans for Toby Farms.

The Council of Delaware County supported two plans in the City of Chester as prosective Federal projects. While supporting flood proofing and flood forecasting, warning, and preparedness plans, Delaware County did not indicate an intent to provide local assurances. They requested additional information on the non-structural plans for local implementation. Chester County was not interested in supporting flood proofing and flood forecasting, warning, and preparedness plans in Chester County.

A summary of the results of coordination for local assurances is presented in Table 5. Plans were not supported because of the following reasons:

Plans involving a dry reservoir were opposed because they required relocations of non-flood prone buildings (Plans S4A, S4B, S4C).

Plans which only protected a few commercial and industrial buildings were not considered appropriate for participation by the local municipalities (Plans L10A, L10B).

Some non-structural plans were felt to be more efficiently implementable by local agencies (Plans FW1, FP1, FI1).

Some plans were opposed because the people to be protected felt that the large size of the protective structures were aesthetically offensive and psychologically confining (Plans L8A, L8B).

Many plans, due to utility and highway relocations and land requirements, would have involved high non-Federal costs. Limited community resources would have meant that if they participated in the plans other needs of the community would have to be postponed for many years (S7A, S4B, S4C, L8A, L8B).

## PLANS CONSIDERED FURTHER

More detailed investigations of Plan L6G and S3A was conducted. A variation (Plan S3Ab) of Plan S3A was also developed. However, these detailed studies showed that all three plans which included a less costly channel alignment were not economically justified. The economic analyses of these plans were based on a January 1978 price level, a discount rate of 6-5/8%, and an economic life of 50 years.

PLAN L6G. As shown on Plate 10, Plan L6G involves replacement of three bridges and widening 1680 feet of channel to a minimum bottom width of 100 feet. The Chester Creek banks would be grassed and a seeded and landscaped barrier would be placed along the Creek. The three bridges and approaches would be raised and lengthened to allow passage of a 100-year flood without backup. Bridges at Second and Third Street would be replaced by a single bridge through construction of U.S.

**TABLE 4**
**SUMMARY OF RESULTS**
**COMBINATION PLANS 1/**

| PLAN 2/ | PROJECT COST | AVERAGE ANNUAL BENEFITS | PERCENT DAMAGE REDUCTION | BCR | REASON ELIMINATED |
|---|---|---|---|---|---|
| S1A | $ 11,090,000 | $ 461,800 | 67% | 0.60 | Unjustified |
| S1B | 17,780,000 | 319,300 | 46 | 0.26 | Unjustified |
| S1C | 22,870,000 | 472,500 | 68 | 0.31 | Unjustified |
| S1D | 25,870,000 | 504,300 | 73 | 0.29 | Unjustified |
| S2A | 11,498,000 | 471,000 | 68 | 0.59 | Unjustified |
| S2B | 15,008,000 | 495,000 | 72 | 0.48 | Unjustified |
| S3B | 5,878,000 | 268,000 | 58 | 0.69 | Unjustified |
| S4A | 11,698,000 | 641,200 | 92 | 0.75 | No Support |
| S4B | 9,382,000 | 581,900 | 84 | 0.92 | No Support |
| S4C | 12,009,000 | 606,700 | 87 | 0.75 | No Support |

1/ Since recreation benefits cannot be used to justify these flood control projects, only flood control benefits and costs are included here.

2/ See Table 3 for description of each system.

TABLE 5
RESULTS OF COORDINATION FOR
LOCAL ASSURANCES

| Alternative Plans which were "Tentatively Recommended" For Further Study | | | Responses to Request for Local Assurances |
|---|---|---|---|
| **Plan Number** | **Type of Plan** | **Plan Location** | |
| L6G | Bridge Modification Channel Widening | City of Chester | Delaware County provided local assurances. Once it is determined which plan (L6G or S3A) is economically & environmentally most acceptable, the County will provide lands, easements and rights-of-way; and operation and maintenance of the completed project. |
| S3A | Channel Realignment | City of Chester | |
| FW1 | Flood Forecasting, Warning, & Preparedness Planning | Chester Creek Basin-entire basin | No assurances were received from Delaware or Chester Counties or any municipalities for these plans. Delaware County has indicated that they might implement these plans, if they are feasible. |
| FP1 | Flood Proofing | Chester Creek Basin-where applicable | |
| | | | Delaware County resolved the remainder of the plans as follows: |
| FI1 | Flood Insurance | Chester Creek Basin all flood plains | FI1 - All eligible residents and municipalities were urged to participate in the National Flood Insurance Program and pledged to continue to assist local government in making use of this important program. |
| L8A | Levee - 100 Year Flood Protection | Toby Farms, Chester Township | L8A & L8B - Neither Chester Township nor Delaware County provided assurances for these plans. Chester Township adopted a resolution not supporting L8A and L8B. |
| L8B | Levee - Standard Project Flood Protection | Toby Farms, Chester Township | |
| L10A | Levees, Floodwalls, & Bridge Modifications-100-Year Flood Protection | Lenni | L10A & L10B - Neither Delaware County nor Aston and Middletown Townships provided local sponsorship for these plans. |
| L10B | Levees, Floodwalls, & Bridge Modifications-Standard Project Flood | Lenni | |
| S4A | Combination of Dry Reservoir & Channel Realignment | Aston, Chester Heights, City of Chester, Concord | S4A, S4B & S4C - Neither Delaware County nor the municipalities in which the projects were located provided local sponsorship for these plans. Chester Heights Borough and Concord Township adopted resolutions opposing plans S4A, B and C. |
| S4B | Combination of Dry Reservoir & Bridge Modifications | Aston, Chester Heights, City of Chester, Concord | |
| S4C | Combination of Dry Reservoir, Bridge & Channel Modifications | Aston, Brookhaven, Chester Heights, Chester Township, City of Chester, Concord, Upland | |

Highway 13 (PA Route 291). About 3.2 acres of land would be required. Maintenance dredging of the channel would be required every five years.

This plan provides some protection by reducing flood stages over a range of flows. The 100-Year Flood depths of up to 18 feet above bank would be reduced by about 3 feet. Flood depths would be reduced from about Fifth Street upstream to Toby Farms, a distance of about 3-1/4 miles.

A summary of the costs is presented below.

PLAN L6G

PROJECT COST

| Item | Cost |
|---|---|
| Channel and Transition | $ 527,000 |
| Bridges and Roads | 1,463,000 |
| Contingencies @ 25% | 497,000 |
| Real Estate | 22,000 |
| Engineering & Design, Supervision and Administration @ 15% | 377,000 |
| Total First Cost | $2,886,000 |

AVERAGE ANNUAL COST

| | |
|---|---|
| Project Cost Amortized (50-Years) | $ 199,300 |
| Annual Operation and Maintenance | 7,400 |
| Total Annual Cost | $ 206,700 |

Flood control benefits are realized through reducing damages to existing flood prone structures for existing and future conditions. Future damages result from increases in the value of furnishings of residential properties and increased flood levels. Due to increased development of upstream lands existing and future benefits represent a 23% reduction in total average annual damages of $598,800 for the areas protected. Flood control benefits total $136,300.

Additional benefits were claimed for advance replacement of bridges and for providing employment to previously unemployed workers. Benefits for preventing traffic delays due to flooding were considered. Their potential was not significant in justifying a project. They were not computed.

The highest benefit to cost ratio is 0.76 to 1.0. This results from using existing and future flood control benefits and inundation reduction, advance bridge replacement and employment benefits .

The significant impacts of plan L6G are summarized in Table 6. The plan's ability to solve the flooding problems is not sufficient. The plan is not economically justified. The impacts of construction

**TABLE 6**
**SIGNIFICANT EFFECT ASSESSMENTS**
**PLAN L6G**

| EFFECTS OF PLAN | | ASSESSMENT DURATION 1/ | ASSESSMENT TYPE 2/ |
|---|---|---|---|
| National Economic Development | | | |
| Inundation reduction benefits (existing) | = 109,100 | P | B |
| Affluence and urbanization benefits | = 27,200 | P | B |
| Advance bridge replacement benefits | = 7,500 | T | B |
| Increased employment benefits | = 12,900 | T | B |
| Project First Cost | =2,866,000 | P | A |
| O&M Cost | = 7,400 | P | A |
| Minor alteration of business patterns during construction | | T | A |
| Regional Development | | | |
| Increased employment during project construction and maintenance operations. | | T | B |
| Disruption of transportation during construction. | | T | A |
| Minor alteration of business patterns during construction. | | T | A |
| Increased output of goods and services in Basin. | | P | B |
| A 23% reduction of the $598,800 in annual damages in the areas protected. | | P | B |
| Environmental Impact | | | |
| Adverse effects on aquatic life during construction. | | T | A |
| Loss of natural bank vegetation during construction. | | T | A |
| Acoustic, aesthetic, and air quality degradation during project construction. | | T | A |
| Historic sites will continue to be flooded. | | P | A |
| No known archeological sites are in the project area. | | P | - |
| Alteration of natural environment by the disposal of excavated materials for project construction and maintenance. | | P | A |
| Social Well-Being | | | |
| Loss of transportation and utility services during construction. | | T | A |
| No significant effect on recreation potential. | | P | - |
| Loss of parking facilities. | | P | A |
| Slight reduction of emergency losses and disruption of public services. | | P | B |

1/ Duration indicates if the effect is permanent (P) or temporary (T)
2/ Type indicates if the effect is beneficial (B), adverse (A), or no change (-).

and maintenance are generally adverse. This plan can not be considered for implementation by the Federal Government.

Several changes were made to this plan since it was originally presented to local interests. Previously no new bridge was needed at Sixth Street. The City of Chester later identified this street as being needed; therefore, the bridge must be replaced. Previous work on Seventh Street was for an additional span over the widened channel. However, a new bridge and approaches are required in order that a 100-year flow can be passed without constriction. Transitions upstream of Sixth Street and downstream of the Amtrak viaduct were added to improve hydraulic performance. Additional costs arose for excavating through asphalt, rock and random materials which were previously not identified. Flood control benefits were reduced to account for the twenty-three homes and 15 businesses which have been removed or are planned for removal in the project area.

PLAN S3A. As shown on Plate 11 , Plan S3A involves a new channel from Eyre Park to Third Street or a distance of about 2,900 feet. The new trapezoidal channel would be 50-foot wide at the bottom. The channel would be seeded upstream of Seventh Street and riprap lined downstream. The old channel would be filled in. In order for stormwater to drain naturally to the new channel, the overbank areas would be filled and graded for distances of up to about 500 feet. These surfaces would then be seeded and landscaped. New bridges would be built over the realigned Creek with the old bridges being demolished and replaced by highway section except at Ninth Street. The new bridges span would be elevated to pass the 100-year flood. The Second and Third Street Bridge will be replaced by a single bridge through construction of U.S. Highway 13 (PA Route 291).

Modifications to the High School facilities include: removal or modifications to existing floodwalls and levees; new levees on both sides of the channel; backfill 2000 feet of existing channel downstream of I-95; removal of the pedestrian bridge at Sproul Street. The High School's new parking lot would have to be relocated and new access provided to the parking lot, athletic fields, and YMCA. A footbridge would be provided to provide access from the High School to the parking lot and fields. In addition, relocation of the new practice football field may be required. The municipal parking lot, between Sixth and Seventh Streets, would be reconstructed.

Acquisition and demolition of 15 homes and 6 commercial or industrial buildings would be required. The relocation of the playground of the Day Care Center at Sixth and Penn Streets is also needed.

This plan reduces flood stages over a range of flows. The 100-year flood depths of up to 18 feet above bank would be reduced by about 5 feet. At both the lower and higher flood levels, stages are actually

increased in downstream reaches. The new channel contains the 10 year storm within its banks.

A summary of the costs is presented below.

PLAN S3A

PROJECT COST

| Item | Cost |
|---|---|
| Channel and Transition (including backfill of existing channel) | $1,888,000 |
| Bridges and Roads | 2,044,000 |
| Eyre Park and Sxith Street Modifications | 388,000 |
| Contingencies @ 25% | 1,080,000 |
| Real Estate & Relocations | 1,171,000 |
| Engineering and Design, Supervision & Administration @ 15% | 986,000 |
| Total First Cost | $7,557,000 |

AVERAGE ANNUAL COST

| | |
|---|---|
| Project Cost Amortized (50-Years) | $ 521,800 |
| Annual Operation and Maintenance | 10,000 |
| Total Annual Cost | $ 531,800 |

Flood control benefits are realized through reducing damages to existing flood prone structures for existing and future conditions. Future damages result from increases in the value of furnishings of residential properties and increased flood levels due to increased development of upstream lands. Existing and future benefits represent a 35% reduction in total average annual damages of $598,800 for the areas protected. Flood control benefits total $208,200

Additional benefits were claimed for advance replacement of bridges and for providing employment to previously unemployed workers. Benefits for preventing traffic delays due to flooding were considered. Their potential was not significant to justifying a project. They were not computed.

The highest benefit to cost ratio is 0.48 to 1.0. This results from using existing and future flood control benefits and advance bridge replacement and employment benefits.

The significant impacts of plan S3A are summarized in Table 7. Plan S3A reduces the effect of Creek bends and constricting bridges on flood levels. Real estate costs are high because several businesses and homes in the area must be purchased and its inhabitants relocated. Plan S3A does not eliminate the flooding problems and the

TABLE 7
SIGNIFICANT EFFECT ASSESSMENTS
PLAN S3A

| EFFECTS OF PLAN | | ASSESSMENT DURATION 1/ | TYPE 2/ |
|---|---|---|---|
| National Economic Development | | | |
| Inundation reduction benefits (existing) | = $ 162,700 | P | B |
| Affluence and urbanization benefits | = 45,500 | P | B |
| Advance bridge replacement benefits | = 21,900 | T | B |
| Increased employment benefits | = 27,600 | T | B |
| Project First Cost | = 7,551,000 | P | A |
| O & M Cost | = 10,000 | P | A |
| Minor alteration of business patterns during construction | | T | A |
| Regional Development | | | |
| Increased employment during construction and maintenance operations. | | T | B |
| Disruption of transportation during construction. | | T | A |
| Minor alteration of business patterns during construction. | | T | A |
| Increased output of goods and services in Basin. | | P | B |
| A 35% reduction in the $598,800 annual damages in the protected areas. | | P | B |
| Decreased tax base and employment population caused by changes in flood plan use. | | P | A |
| Environmental Impact | | | |
| Adverse effects on aquatic life during construction. | | T | A |
| Loss of natural bank vegetation during construction. | | T | A |
| Acoustic, aesthetic, and air quality degradation during project construction. | | T | A |
| Historic sites will contine to be flooded. | | P | A |
| No known archeological sites are in the project area. | | P | - |
| Alteration of natural environment by the disposal of excavated materials for project construction and maintenance. | | P | A |
| Social Well-Being | | | |
| Loss of transporation and utility services during construction. | | T | A |
| Reduction of emergency losses and disruption of public services. | | P | B |
| No significant effect on recreation potential. | | P | - |
| Loss of parking facilities. | | P | A |
| Elimination of portions of neighborhoods. | | P | A |
| Elimination of flood threat for evacuated businesses and homes. | | P | B |

1/ Duration indicates if the effect is permanent (P) or temporary (T).
2/ Type indicates if the effect is beneficial (B), adverse (A), or no change (-).

reduction of the problem is not significant. The plan is not economically justified. The impacts of construction are generally adverse. This plan can not be considered for implementation by the Federal Government.

Several changes were made to this plan since it was originally presented to local interests. The new channel was shifted north for about 150 feet and extended to Third Street. Modifications to the athletic facilities and parking area at the High School are now required. The City of Chester changed its traffic circulation pattern since this plan was originally presented, making replacement of the Sixth Street Bridge necessary. More extensive work was also required for the parking lot between Seventh and Sixth Streets, to correct drainage problems which would be created by the realigned Creek. Additional costs arose for excavating in rock, the need for more utility and drainage relocations and a channel transition at the railroad viaduct.

PLAN S3Ab. Plan S3Ab was investigated to try to improve the economic performance of Plan S3A.

As shown on Plate 12 , Plan S3Ab involves a new channel from Eyre Park to Third Street for a distance of about 3,200 feet. The new trapezoidal channel would be 50-foot wide at the bottom. The old channel would be filled in where the Creek is realigned and the overbank areas would be filled and graded so stormwater can drain naturally to the new channel. The graded surfaces would be seeded and landscaped. New bridges would be built at Fifth, Sixth, Seventh, and Ninth Streets. The old bridge at Fifth Street would be replaced by highway section. The new bridges would be elevated to pass 100-year flood. The Second and Third Street Bridges would be replaced by a single bridge through construction of U.S. Highway 13 (PA Route 291).

Modifications to the High School facilities include: removal or modifications to existing floodwalls and levees; new levees on both sides of the channel; backfill 2000 feet of existing channel downstream of the I-95; removal of the pedestrian bridge at Sproul Street. The High School's new parking lot would have to be relocated and new access provided to the parking lot, athletic fields, and YMCA. A footbridge would be provided to provide access from the High School to the parking lot and fields. In addition, relocation of the new practice football field may be required.

At the municipal parking lot, between Sixth and Seventh Street, some parking area would be needed for the new channel. Replacement parking would not be provided. A barrier strip of grassed and landscaped land would be provided along the Creek on both sides to improve the Creek's appearance from the parking area and homes on Penn Street. Acquisition and demolition of 29 homes and 8 commercial or industrial buildings would be required.

This plan reduces flood stages over a range of flows. The 100-year flood depth of up to 18 feet above bank would be reduced by about 5 feet. At both the lower and higher flood levels, stages are actually increased in downstream reaches.

A summary of the costs is presented below.

PLAN S3Ab

PROJECT COST

| Item | Cost |
|---|---|
| Channel and Transition (including backfill of existing channel) | $1,219,000 |
| Bridges and Roads | 1,937,000 |
| Eyre Park and Sixth Street Parking Modifications | 216,000 |
| Contingencies @ 25% | 843,000 |
| Real Estate and Relocations | 1,250,000 |
| Engineering and Design, Supervision and Administration @ 15% | 820,000 |
| Total First Cost | $6,285,000 |

AVERAGE ANNUAL COST

| | |
|---|---|
| Project Cost Amortized (50-years) | $ 443,900 |
| Annual Operation and Maintenance | 10,000 |
| Total Annual Cost | $ 443,900 |

Flood control benefits are realized through reducing damages to existing flood prone structures for existing and future conditions. Future damages result from increases in the value of furnishings of residential properties and increased flood levels due to increased development of upstream areas. Existing and future benefits represent a 33% reduction in total average annual damages of $598,800 for the areas protected. Flood control benefits total $200,500.

Additional benefits were claimed for advance replacement of bridges and for providing employment to previously unemployed workers. Benefits for preventing traffic delays due to flooding were considered. Their potential was not significant to justifying a project. They were not computed.

The highest benefit to cost ratio is 0.56 to 1.0. This results from using existing and future flood control benefits and advance bridge replacement and employment benefits.

The significant impacts of plan S3Ab are summarized in Table 8. Plan S3Ab was investigated to try to minimize costs of Plan S3A. The alignment contains gradual bends, but these bends do not measureably

TABLE 8
SIGNIFICANT EFFECT ASSESSMENTS
PLAN S3Ab

| EFFECTS OF PLAN | ASSESSMENT DURATION 1/ | TYPE 2/ |
|---|---|---|
| **National Economic Development** | | |
| Inundation reduction benefits (existing) = 156,700 | P | B |
| Affluence and urbanization benefits = 43,900 | P | B |
| Advance bridge replacement benefits = 21,900 | T | B |
| Increased employment benefits = 26,500 | T | B |
| Project First Cost = 6,285,000 | P | A |
| O&M Cost = 10,000 | P | A |
| Minor alteration of business patterns during construction | T | A |
| **Regional Development** | | |
| Increased employment during construction and maintenance operations | T | B |
| Disruption of transportation during construction | T | A |
| Minor alteration of business patterns during construction | T | A |
| Increased output of goods and services in Basin | P | B |
| A 33% reduction in the $598,800 annual damages in the the protected areas | P | B |
| Decreased tax base and employment population caused by changes in flood plain use | P | A |
| **Environmental Impact** | | |
| Adverse effects on aquatic life during construction | T | A |
| Loss of natural bank vegetation during construction | T | A |
| Acoustic, aesthetic, and air quality degradation during project construction | T | A |
| Historic sites will continue to be flooded | P | A |
| No known archeological sites are in the project area | P | - |
| Alteration of natural environment by the disposal of excavated materials for project construction and maintenance | P | A |
| **Social Well-Being** | | |
| Loss of transportation and utility services during construction | T | A |
| Reduction of emergency losses and disruption of public services | P | B |
| No significant effect on recreation potential | P | - |
| Loss of parking facilities | P | A |
| Elimination of portions of neighborhoods | P | A |
| Elimination of flood threat for evacuated businesses and homes | P | B |

1/ Duration indicates if the effect is permanent (P) or temporary (T).
2/ Type indicates if the effect is beneficial (B), adverse (A), or no change (-).

increase flood stages. This alignment resulted in reduced costs from decreased costs for drainage, earthwork, bridge modifications, and municipal parking lot modifications. Plan S3Ab does not eliminate flooding problems and the reduction of the problem is not significant. The plan is not economically justified. The impacts of construction on the environment are permanent and generally adverse. This plan can not be considered for implementation by the Federal Government.

## COORDINATION

The study has been coordinated with the appropriate Federal, State, and County agencies, all the municipalities, special interest groups, and the general public. This coordination included meetings, workshops, information bulletins, data sheets, and personal correspondence.

Various agencies provided direct support to the study. The types of information (other than published reports) provided included:

Soil Conservation Service - topo and survey data; recon reports; file data

Environmental Protection Agency - file data on water quality and discharges into surface waters

U.S. Fish and Wildlife Service - inventory fish and wildlife resources; investigate impacts of plans on fish and wildlife

U.S. Geological Survey - data on stream flow and water quality

U.S. Department of Housing and Urban Development - flood insurance studies and back-up data

Delaware River Basin Commission - water quality and quantity plans

Pennsylvania Department of Environmental Resources - State Water Plan and COWAMP file data; working drafts

Pennsylvania Fish Commission - input into FWS work

Pennsylvania Game Commission - input into FWS work

Pennsylvania Department of Transportation - topo, surveys, plans, subsurface data

Delaware Valley Regional Planning Commission - regional and local population, land use, and economic projections and inventory data

Delaware County Planning Commission - population, land use, and economic projections and inventory data

Chester County Planning Commission - population, land use, and economic projections and inventory data

Basin Municipalities - zoning, inventory file data, mapping, subsurface data.

The study coordination culminated with the presentation and review of the study findings and recommendations, by both non-Federal and Federal interests.

Seven Federal agencies and thirty-two state, county, and municipal agencies were contacted by letter (included as Exhibit 6 in Appendix 2) in August 1978. Each agency was informed of the study findings and recommendations and was asked to review and comment on the draft report which was inclosed. Three agencies, the U.S. Fish and Wildlife Service, the Pennsylvania Department of Environmental Resources, and Delaware County, responded with letters (included in Appendix 2). The Fish and Wildlife Service supported both the recommendation that no Federal project be authorized and the suggestion that a flood plain management program be implemented by local interests. The Department of Environmental Resources expressed disappointment that the Corps could not build any flood control project but recognized that "the Corps has taken whatever action is within its authority to assure a comprehensive study of the feasibility of flood protection..." They also offered some comments on and corrections to the draft report. Delaware County also expressed disappointment that no flood control projects could be built by the Corps.

Approximately 1400 agencies, businesses, groups, and individuals were sent an invitation to the final public meeting along with an information bulletin. The information bulletin explained the study findings and recommendations. In response a few statements were made at the 30 August 1978 public meeting; others were mailed in. Pennsylvania State Senator Clarence Bell and State Representative Ralph Garzia both disagreed with the Corps' findings, advocating the construction of small in-stream dams, and channelization, respectively. (Both these solutions were investigated in the study. Both were not economically justified.) The Chester County Planning Commission stated that they agreed with the Corps' findings and support the establishment of a flood plain management program. A representative of the City of Chester expressed great disappointment and frustration in no Federal project being recommended there.

## SUMMARY

The 68.7 square mile Chester Creek Basin is located in Chester and Delaware Counties, Pennsylvania. Most people live in the older urban areas, the City of Chester and the Borough of Upland in the lower reaches of the Basin, and West Chester Borough in the basin's headwaters.

There are many water resources problems in the Basin. Water quality, water supply and flood damages are the most apparent. The study was authorized to investigate solutions to these and other water and related land resources needs. In compliance with the desires of the Commonwealth of Pennsylvania and other regional water and land resource planning agencies, and in view of other on-going studies this study was redirected from a comprehensive undertaking to a flood control and flood plain management effort. Some consideration was given to water supply and recreation needs in this study.

Periodic flooding has occurred since the Basin was first settled in 1643. Average annual damages in the Basin are estimated at $720,300 in 1978, and projected to reach $1,199,000 by 2035. About 66 percent of this projected increase results from increases in urban runoff resulting from expected development in upland areas.

About 54 percent of existing annual damages occur in the City of Chester, Upland Borough and Chester Township. About 80 percent of Standard Project Flood damages occur in these three communities. The Goose Creek Watershed in West Chester Borough and West Goshen Township is the area with the second greatest concentration of damages. About 18 percent of the total. Very shallow but frequent flooding occurs. About 65 percent of the annual damages of $151,000 occur at the 10-year flood level.

The worst flood occurred on 13 September 1971. Over 130 businesses and 732 homes were flooded. Eight lives were lost. Total flood costs (in January 1978 dollars) was estimated at $26,138,000. Of these losses, about 65 percent were to commercial, industrial and public facilities. About 24 percent of those losses were to residential properties. Many properties were removed from flood prone areas following this flood. If that flood were to occur again damages would be $17,600,000.

Forty-seven plans for preventing or reducing flood damages and threat to human life were considered. These included both structural and non-structural measures applied both on a basin-wide basis and individually at specific problem areas.

The number of plans which either partially or totally addressed each community with major flood problems were as follows: Entire Basin (17); Aston Township (6); Brookhaven Borough (2); Chester Heights Borough (1); Toby Farms area in Chester Township (6); City of Chester (20); Goose Creek Watershed in West Chester Borough and West Goshen Township (3); Middletown Township (3); and Upland Borough (6).

An iterative process was employed in the identification, development, assessment and evaluation of the flood control plans. During the screening of alternative plans twelve were identified as having potential for development as solutions to the flood problems. These plans were recommended for further consideration. All other plans were eliminated from further consideration because they were not practical solutions, not very effective in solving the problems in the Basin, not economically justified, or clearly non-Federal responsibilities.

In this screening, no plans were eliminated because of harmful environmental or social impacts. However, the significant impacts of all plans were identified, and considered in evaluations. It was proposed that investigation and quantification of environmental and social impacts and possible mitigative measures would take place during subsequent iterations of the planning process. Consideration was given to all feasible flood control plans, and not constrained to only those traditionally used by the Corps.

Extensive coordination took place with State, County and municipal officials and the general public on the twelve plans. Information on all plans considered was presented. Only two plans in the City of Chester were supported by local interests for potential development by the Corps.

The ten plans which had the potential to help solve the flooding problems, but were not supported for development by the Corps, included:

Plans S4A, S4B and S4C, which involved a dry reservoir on the West Branch Chester Creek and channel and bridge modifications along the main stem Chester Creek.

Plans L10A and L10B which involved levees (at 100-year and SPF level protection) along the main stem and West Branch Chester Creek near Lenni.

Plans L8A and L8B which involved levees (at 100-year and SPF level protection) along the main stem Chester Creek, at Toby Farms, Chester Township.

Plans FW1, FP1 and FI1 which involved flood warning and preparedness planning, flood proofing and flood insurance protection through out the Basin.

Further investigations of the two plans in the City of Chester resulted in large increases in costs and no increases in benefits. The plans were not economically justified.

The best solution to the Basin's flooding problems is a flood plain management program and maintenance of the stream channels under bridges. The flood plain management program would reduce existing flood damages and the threat to life through measures such as flood warning and flood proofing. Through land management measures such as flood plain zoning and permanent evacuation, flood prone structures would eventually be removed and non-compatible activities would be prevented from locating in flood plains. The non-structural program should consist of the following:

Existing Flood Plain Encroachments. All future actions in the flood plains should be done with a knowledge and consideration of flooding. As existing structures such as bridges and buildings deteriorate, they should be removed. This removal will reduce damages and lower flood stages. If structures or bridges are replaced, this should be done so as to not restrict flood flows. Investigations of more than six bridge modification plans in this study have shown that flood damages can be eliminated by replacing bridges with structures of adequate carrying capacity.

Flood Plain Zoning and Floodway Ordinance. Zoning in compliance with the National Flood Insurance Program is required. Adoption of stronger ordinances should be considered because of the significant stages of the Standard Project Flood, high damages at that flood level, and possible loss of life. Adoption of more stringent ordinances to account for probable increases in the frequency and level of flooding caused by development of upstream areas should also take place.

Land Development Regulations in Upland Areas. Regulations should be enforced for on-site detention of stormwater runoff. This will prevent future increases in flooding due to future urbanization.

Flood Insurance. Complete participation of all their floodplain population in the National Flood Insurance Program should be promoted by the communities in the Basin. Due to the high risks involved people should strive to keep the coverage current and at the maximum level allowed.

Permanent Flood Plain Evacuation. Removal of existing flood plain structures cannot be justified solely on flood control benefits. However, reduction of flood damages should always be considered as strong supportive justification for removal of buildings for redevelopment, open spaces, parking lots, and recreation areas.

Flood Proofing. The practicality of implementing a large plan for flood proofing private property by a government agency in the Chester Creek Basin is remote. Flood proofing can reduce interior flood damages for about half of the buildings in the flood plain.

Caution should be used since indiscriminant application of flood proofing measures can result in increased damages due to failure of walls and floors.

Flood Forecasting, Warning and Preparedness Planning. A well structured system which includes detailed plans for action is needed. Such a system can be effective in reducing damages and the loss of life.

The program would be developed, implemented and administered by local governments. Local governments should become aware of and seek the assistance of Federal programs for development and implementation. Assistance is available by the National Weather Service (NOAA), the U.S. Department of Housing and Urban Development, and Army Corps of Engineers.

Maintenance of adequate stream capacity is needed. There are over 29 bridges crossing the first 10 miles of the Chester Creek. Nine of these bridges are in the City of Chester. Over six channel clearance plans were investigated in this study. The findings were that channel clearance was not costly and could prevent flood damages if undertaken at regular intervals. This work should be done by local interests as part of normal maintenance of these bridges.

## STATEMENT OF FINDINGS

As District Engineer of the Philadelphia District, Corps of Engineers, I have reviewed and evaluated, in light of the overall public interest, all available data and documents concerning the proposed actions, as well as the stated views of other agencies and the concerned public, relative to the various alternative plans for providing for water resources needs of the Chester Creek Basin, Pennsylvania.

Many other agencies are conducting studies to solve most of the water resources needs in the Basin. Following a review of their planned efforts, an understanding of what these studies could accomplish, and at the direct request of these agencies, the Chester Creek Study was redirected to solving the flood control problems.

I have considered numerous measures for solving the flooding problems. No improvement for flood control should be authorized at this time because of:

Lack of economic justification of most plans.

Opposition by local residents and officials to several plans.

The stated inability of Delaware County and local communities to financially support some plans.

The non-interest of local officials to assume liability and provide public monies for flood control improvement to private properties.*

Implementation of several plans is clearly not a Corps responsibility.

The best solution is for local interests to implement a flood plain management program for the Chester Creek Basin and to undertake channel clearance under existing bridges.

This action, as developed in various sections of this report and presented in the Summary, would consist of corrective and preventive measures for reducing the adverse effects of flooding. This action is the best solution because of:

Lack of economic justification of most structural measures.

Indications of economic justification for non-structural measures, and relatively low costs.

Indication of economic justification for bridge clearance work, and relatively low costs.

Strong support of non-structural solutions by Delaware County.

Overall good participation of communities in the Basin in the National Flood Insurance Program.

Minimal adverse impacts of these measures, the potential to preserve the natural floodplain environment, and over time the potential to restore the natural environment.

The possible consequences of the plans considered and action proposed have been studied for environmental, social well-being, and economic effects, including regional and national economic development and engineering feasibility. Other factors bearing on my review include the flash flooding nature of the problem, the large increase in damages expected as the result of future development of upstream areas, and the eight lives lost in the flood of record and future risk of the loss of lives.

I have determined that formulation of an environmental quality plan is not warranted because economically justified and implementable plans to satisfy the flood control needs in the Chester Creek Basin could not be developed.

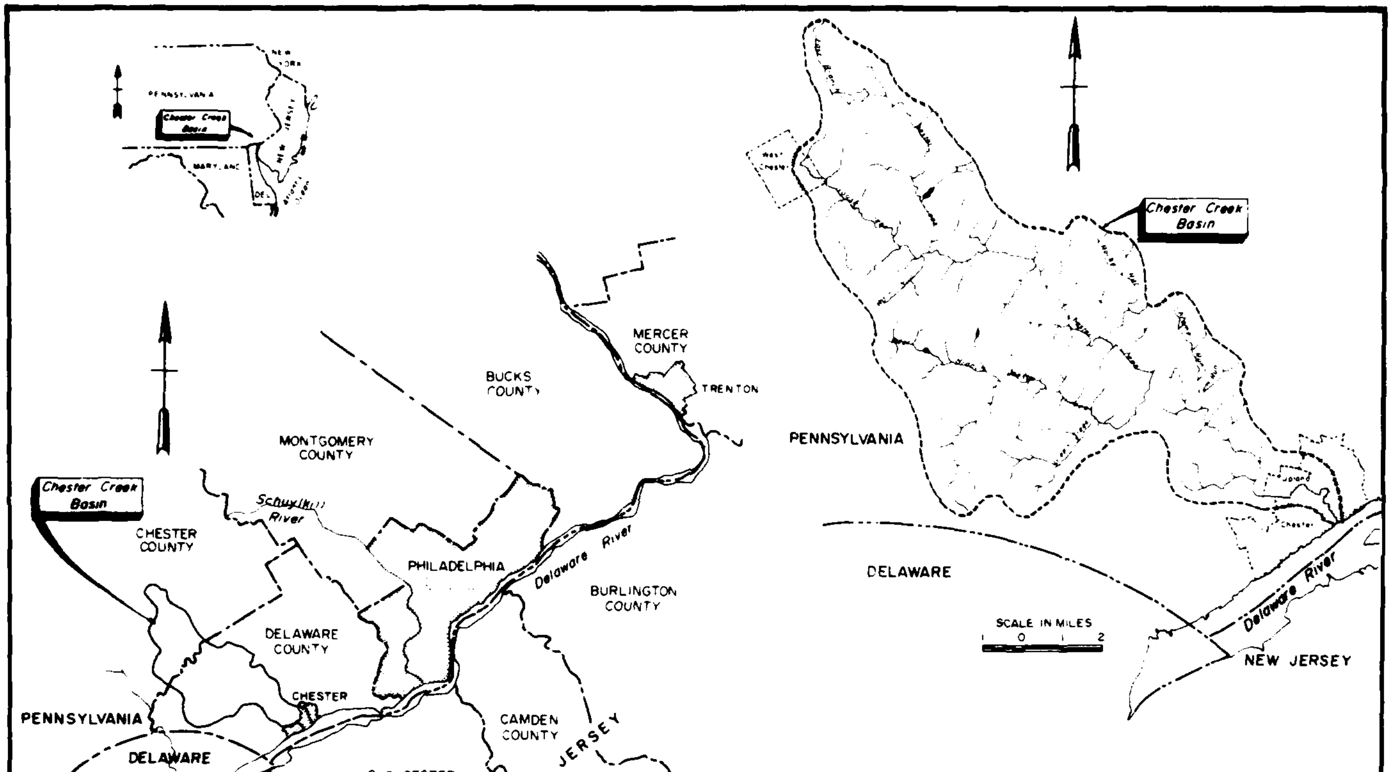
* Applies to flood proofing of private property.

## RECOMMENDATIONS

It is recommended that no improvements for flood control in the Chester Creek Basin be authorized by the United States at this time.

James G. Ton

JAMES G. TON
Colonel, Corps of Engineers
District Engineer

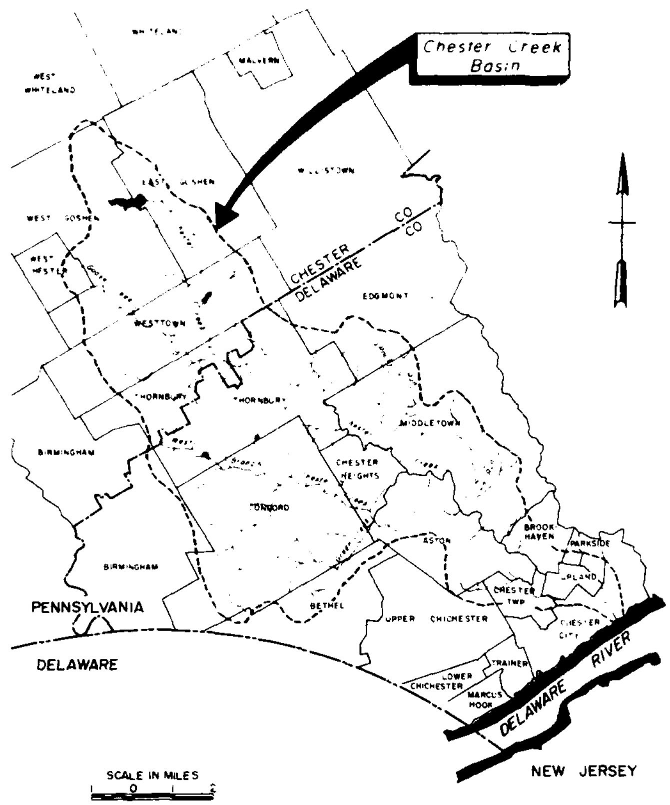



CHESTER CREEK BASIN, PENNSYLVANIA

STUDY AREA LOCATION

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE I




POLITICAL SUBDIVISION

DELAWARE COUNTY

ASTON TOWNSHIP
BETHEL TOWNSHIP
BIRMINGHAM TOWNSHIP
BROOKHAVEN BOROUGH
CITY OF CHESTER
CHESTER HEIGHTS BOROUGH
CHESTER TOWNSHIP
CONCORD TOWNSHIP
EDGMONT TOWNSHIP
MIDDLETOWN TOWNSHIP
PARKSIDE BOROUGH
THORNBURY TOWNSHIP
UPLAND BOROUGH
UPPER CHICHESTER TOWNSHIP

CHESTER COUNTY

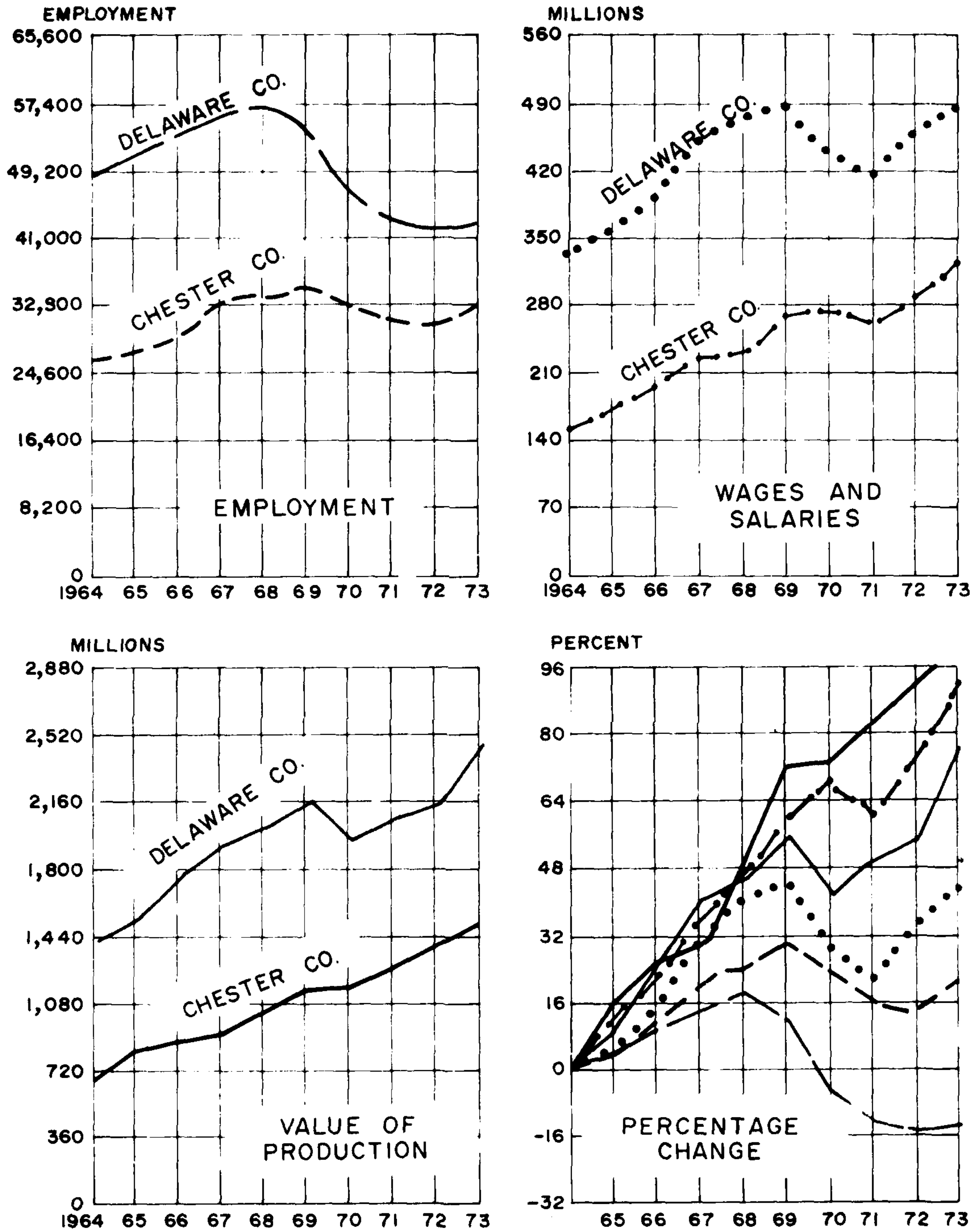
BIRMINGHAM TOWNSHIP
EAST GOSHEN TOWNSHIP
THORNBURY TOWNSHIP
WEST GOSHEN TOWNSHIP
WEST CHESTER BOROUGH
WESTTOWN TOWNSHIP
WEST WHITELAND TOWNSHIP

CHESTER CREEK BASIN, PENNSYLVANIA

POLITICAL SUBDIVISIONS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE 2




CHESTER CREEK BASIN, PENNSYLVANIA

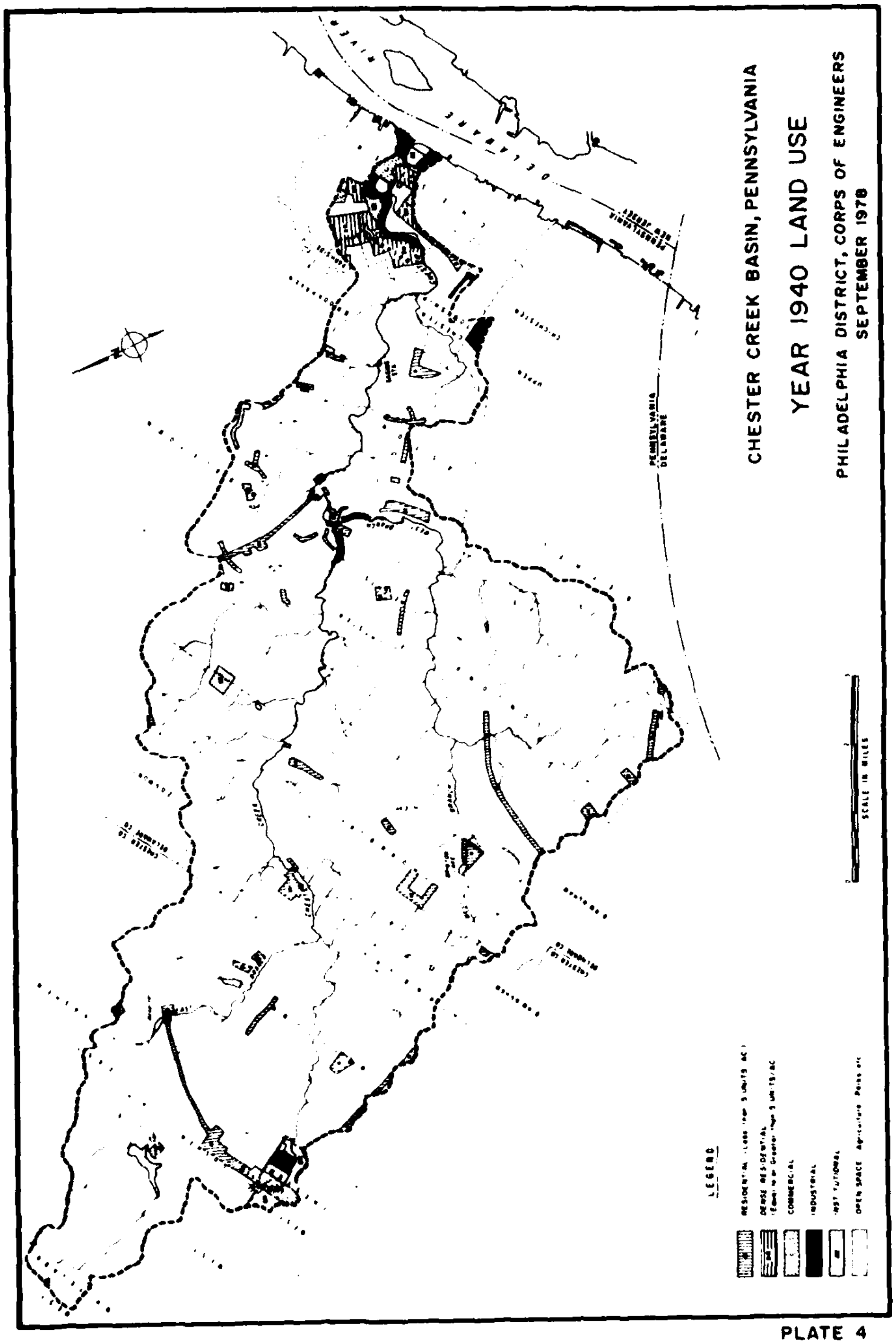
**TEN YEAR**

**COUNTY ECONOMIC REVIEW**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

PLATE 3



CHESTER CREEK BASIN, PENNSYLVANIA
YEAR 1940 LAND USE
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978
PENNSYLVANIA
DELAWARE
LEGEND
RESIDENTIAL
DENSE RESIDENTIAL
COMMERCIAL
INDUSTRIAL
INSTITUTIONAL
OPEN SPACE
SCALE IN MILES


PLATE 4

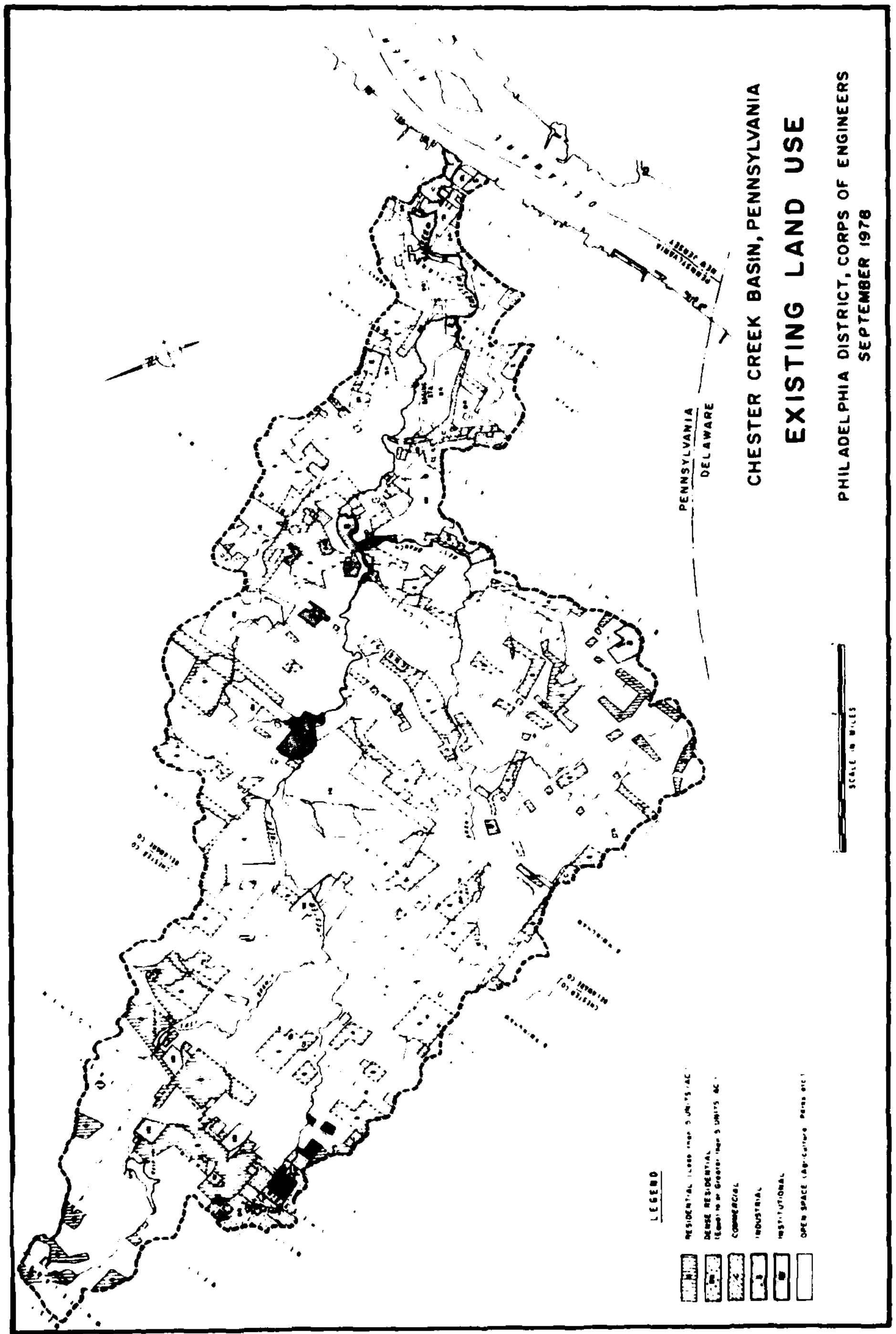

CHESTER CREEK BASIN, PENNSYLVANIA
EXISTING LAND USE
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978
PENNSYLVANIA
DELAWARE
LEGEND
COMMERCIAL
INDUSTRIAL
INSTITUTIONAL

PLATE 5

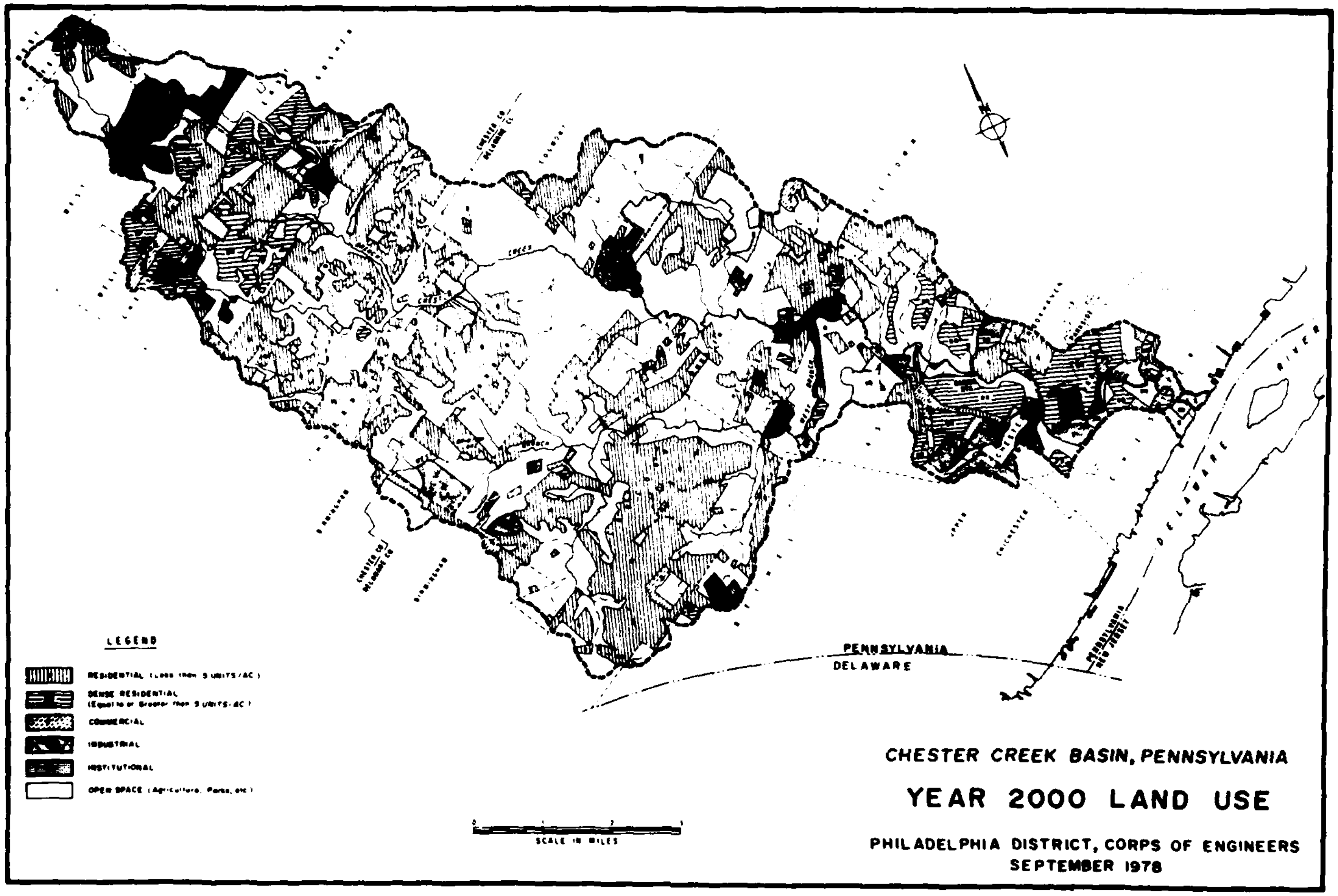

LEGEND
RESIDENTIAL (Less than 5 UNITS/AC)
DENSE RESIDENTIAL (Equal to or Greater than 5 UNITS/AC)
COMMERCIAL
INDUSTRIAL
INSTITUTIONAL
OPEN SPACE (Agriculture, Parks, etc.)
SCALE IN MILES
PENNSYLVANIA
DELAWARE
DELAWARE RIVER
CHESTER CREEK BASIN, PENNSYLVANIA
YEAR 2000 LAND USE
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE 6

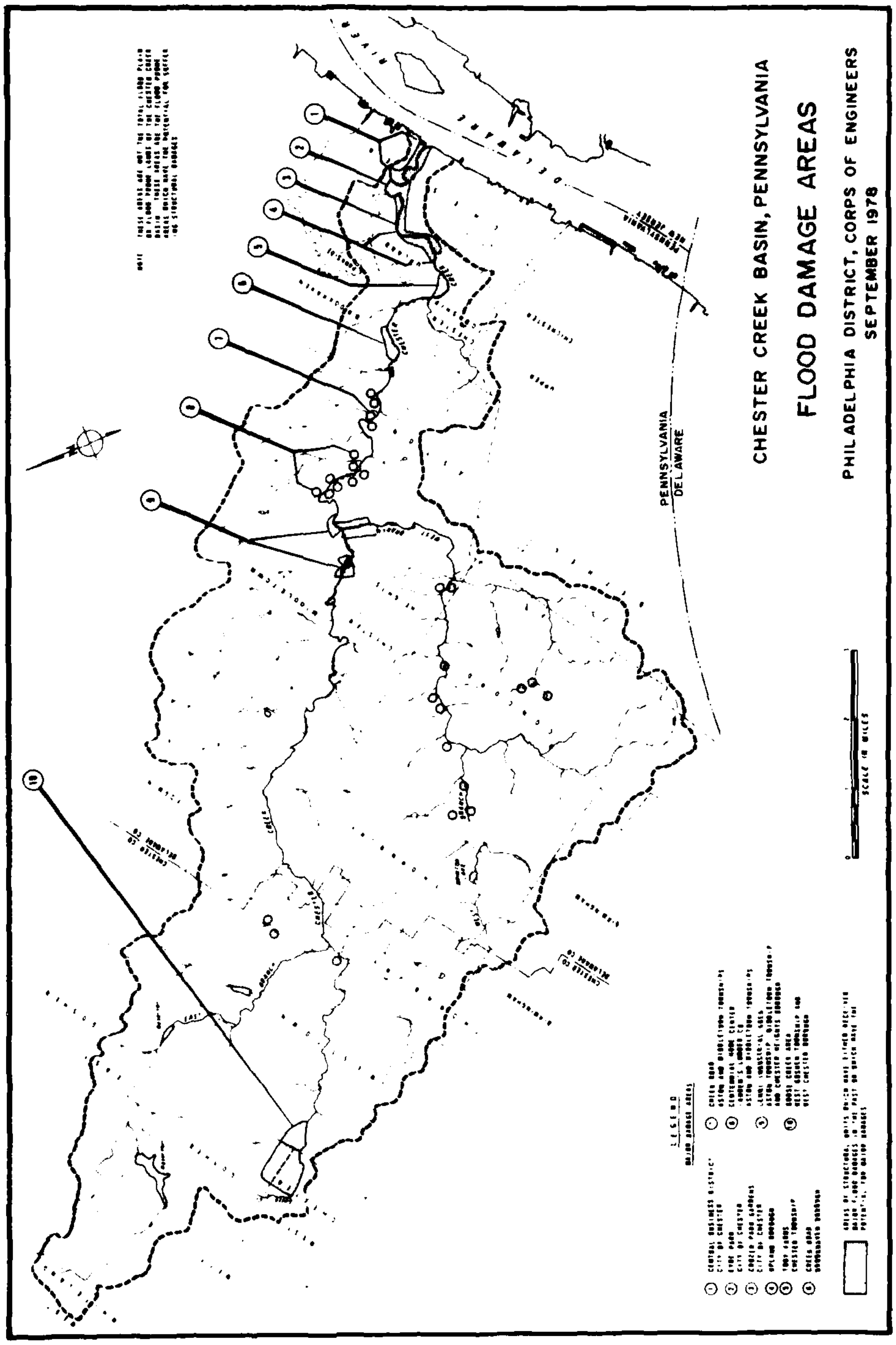
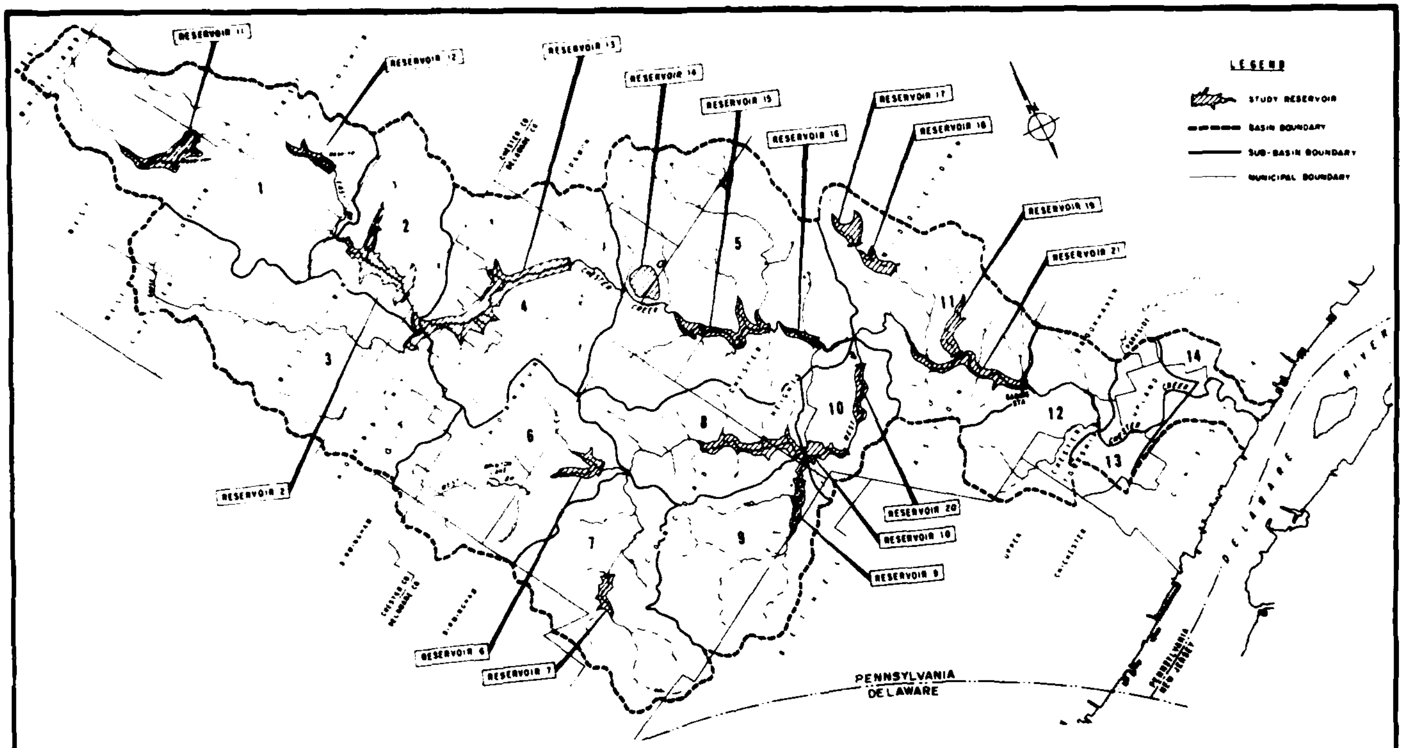

CHESTER CREEK BASIN, PENNSYLVANIA
FLOOD DAMAGE AREAS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978
PENNSYLVANIA
DELAWARE

PLATE 7




**NOTE:**
ONLY RESERVOIR SITES WHICH WERE NOT SCREENED OUT DURING PRELIMINARY ANALYSIS ARE SHOWN

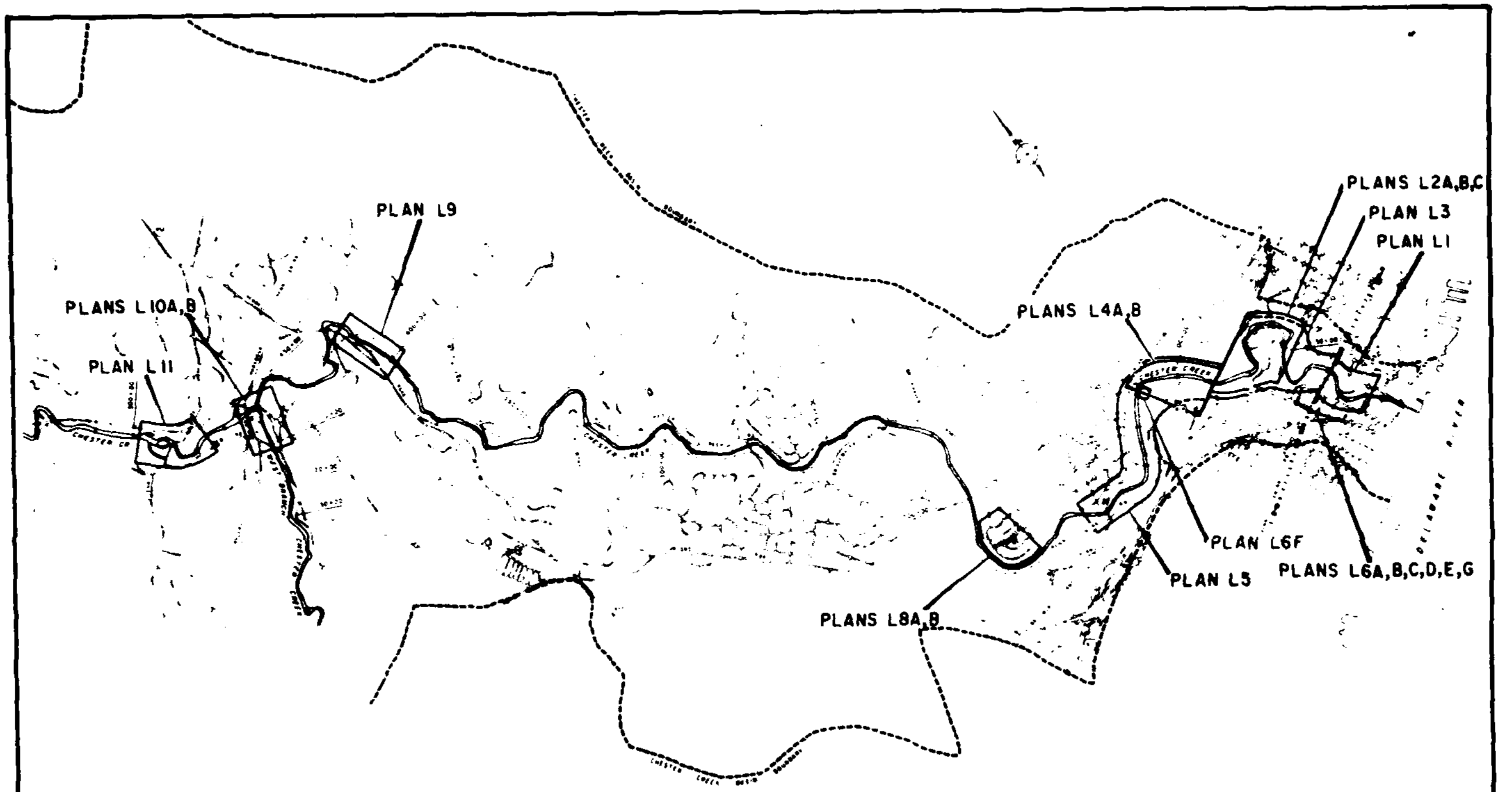
SCALE IN MILES

CHESTER CREEK BASIN, PENNSYLVANIA

## LOCATION OF RESERVOIR PLANS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

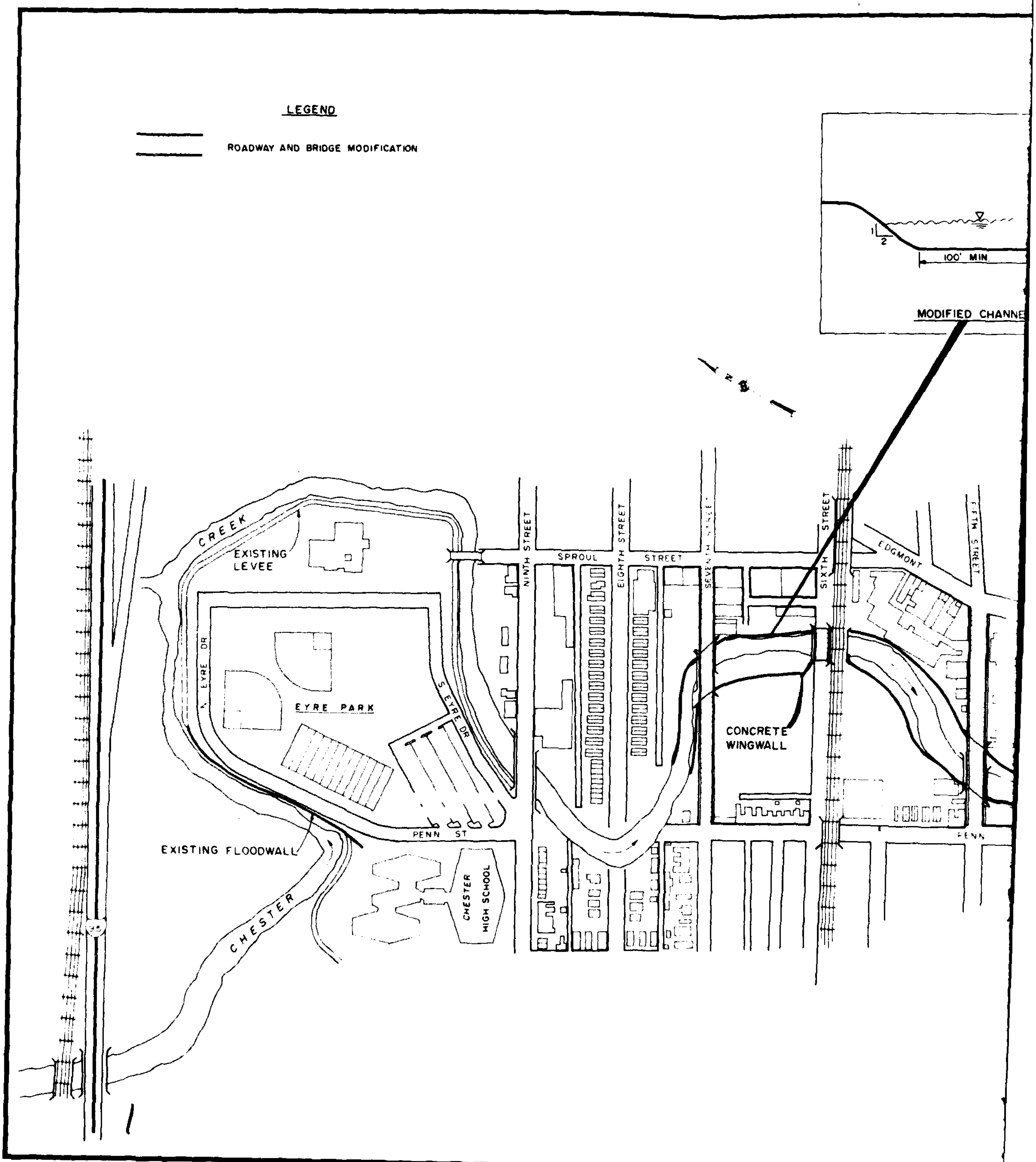
PLATE 8



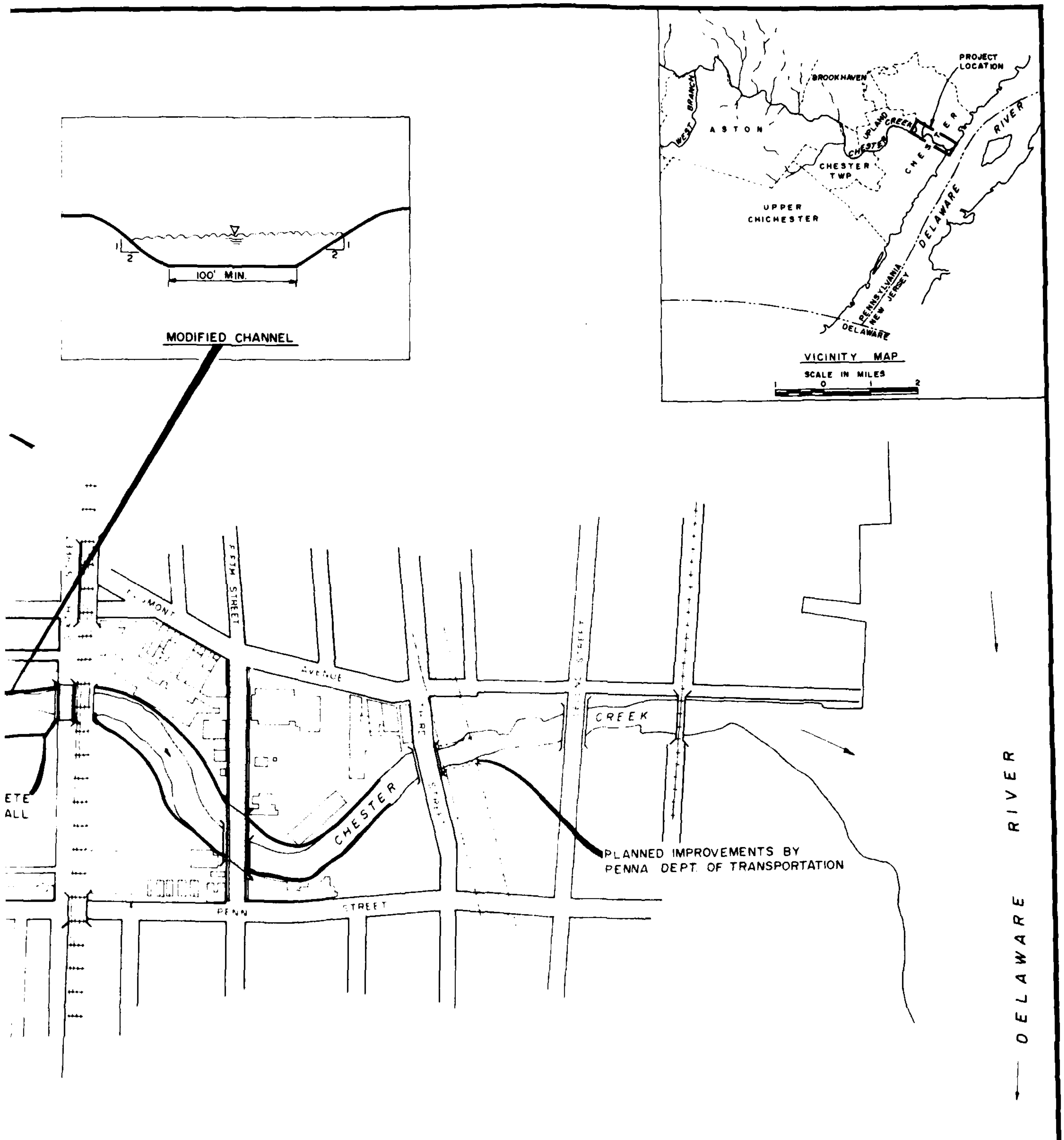

NOTE PLANS NOT SHOWN
- PLANS L7A, L7B - CHANNEL DREDGING, STA 9+00 TO STA 285+00
- PLANS L7C, L7D - CHANNEL DREDGING, STA 50+00 TO STA 185+00

SCALE IN FEET

CHESTER CREEK BASIN, PENNSYLVANIA
LOCATION OF
LOCAL IMPROVEMENT PLANS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978



LEGEND
ROADWAY AND BRIDGE MODIFICATION
100' MIN
MODIFIED CHANNE
CREEK
EXISTING LEVEE
EYRE PARK
N. EYRE DR
S. EYRE DR
PENN ST
EXISTING FLOODWALL
CHESTER
CHESTER HIGH SCHOOL
NINTH STREET
SPROUL
STREET
EIGHTH STREET
SEVENTH STREET
SIXTH STREET
EDGMONT
FIFTH STREET
CONCRETE WINGWALL
PENN




2

CHESTER CREEK BASIN, PENNSYLVANIA

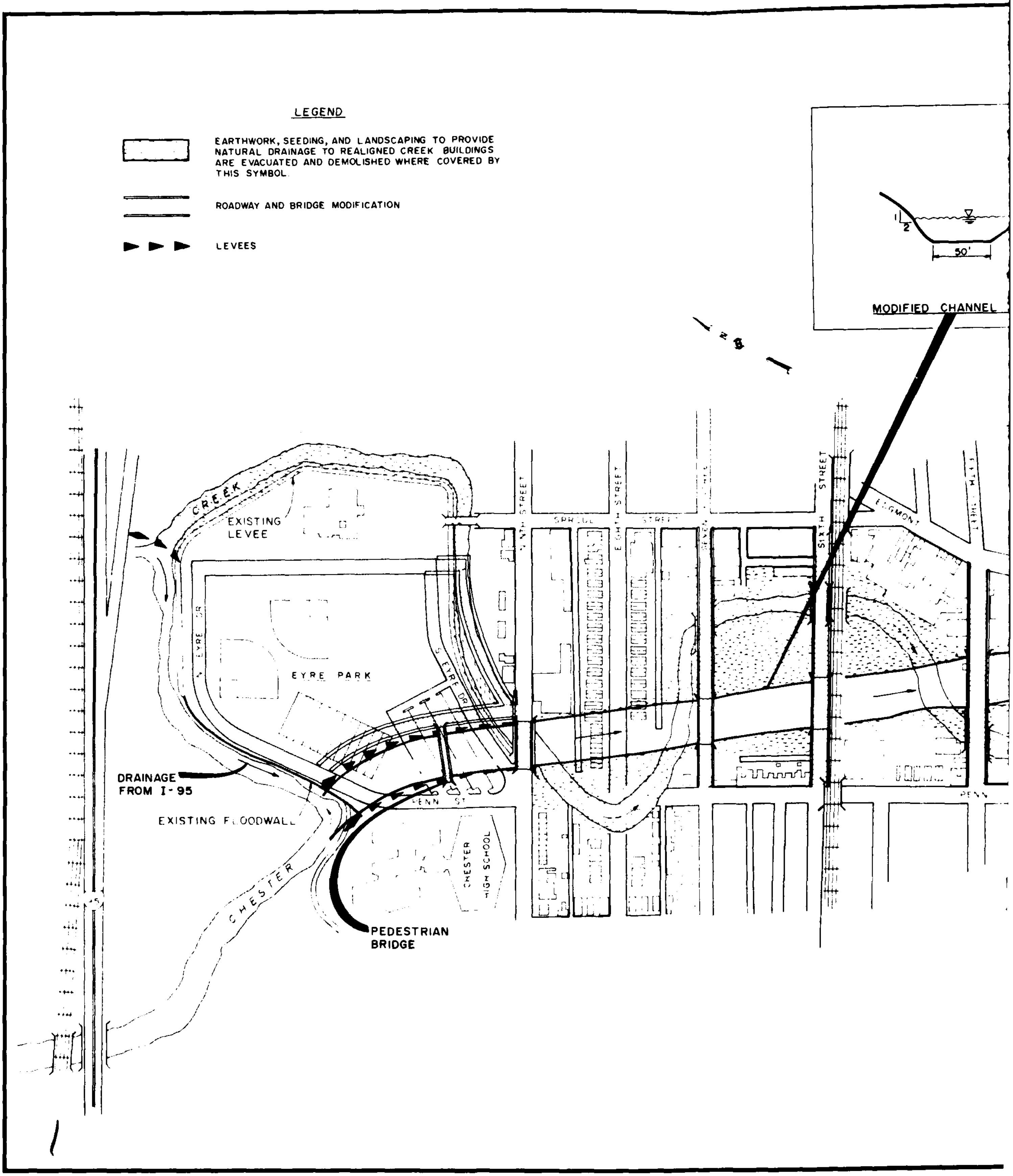
**CHANNEL AND BRIDGE MODIFICATIONS**

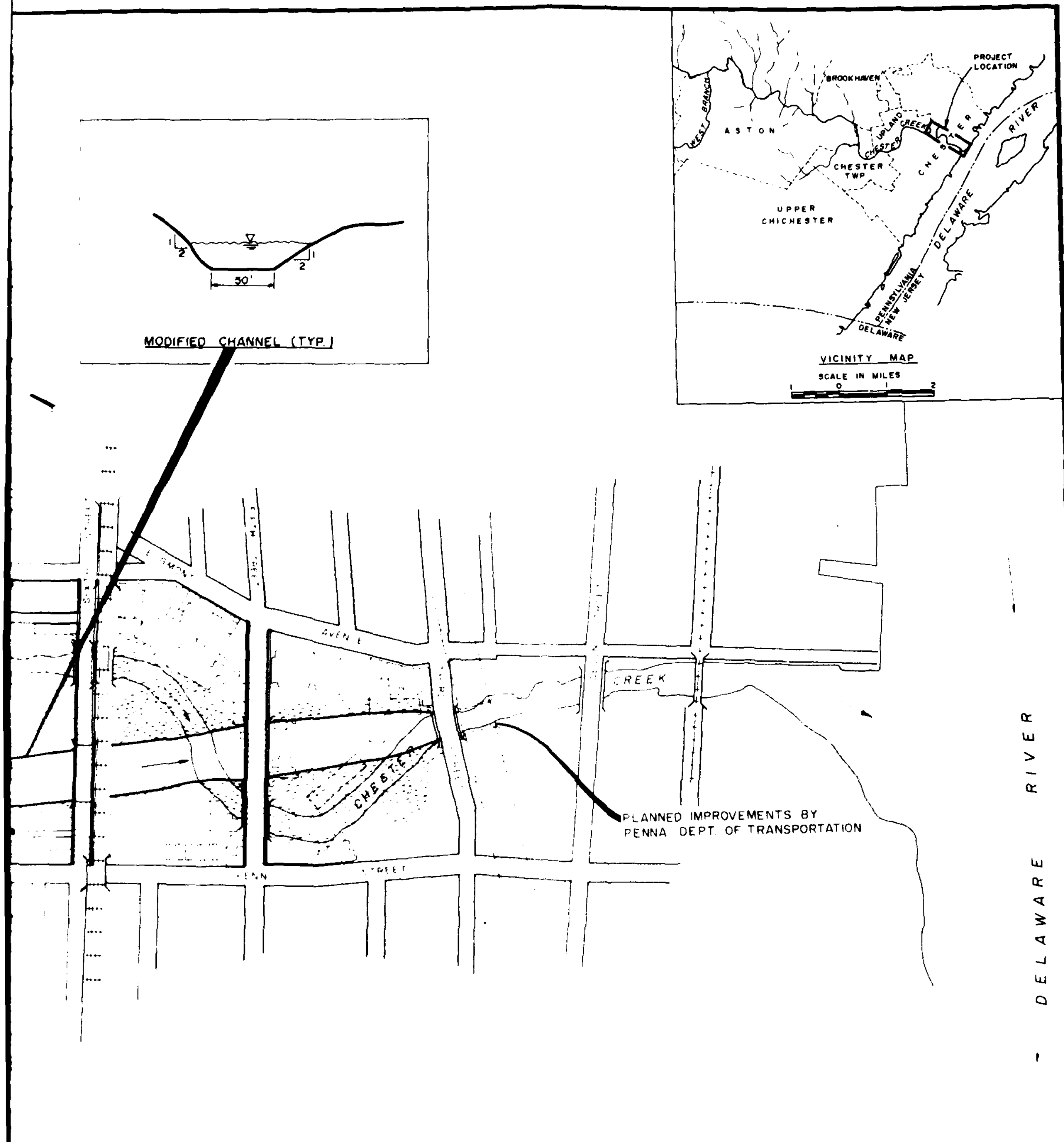
**PLAN L6G**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

PLATE 10


LEGEND
EARTHWORK, SEEDING, AND LANDSCAPING TO PROVIDE NATURAL DRAINAGE TO REALIGNED CREEK BUILDINGS ARE EVACUATED AND DEMOLISHED WHERE COVERED BY THIS SYMBOL.
ROADWAY AND BRIDGE MODIFICATION
LEVEES
50'
MODIFIED CHANNEL
CREEK
EXISTING LEVEE
EYRE PARK
SPRUCE STREET
NINTH STREET
EIGHTH STREET
SEVENTH
SIXTH STREET
EGMONT
FIFTH STREET
PENN ST
DRAINAGE FROM I-95
EXISTING FLOODWALL
CHESTER
CHESTER HIGH SCHOOL
PEDESTRIAN BRIDGE



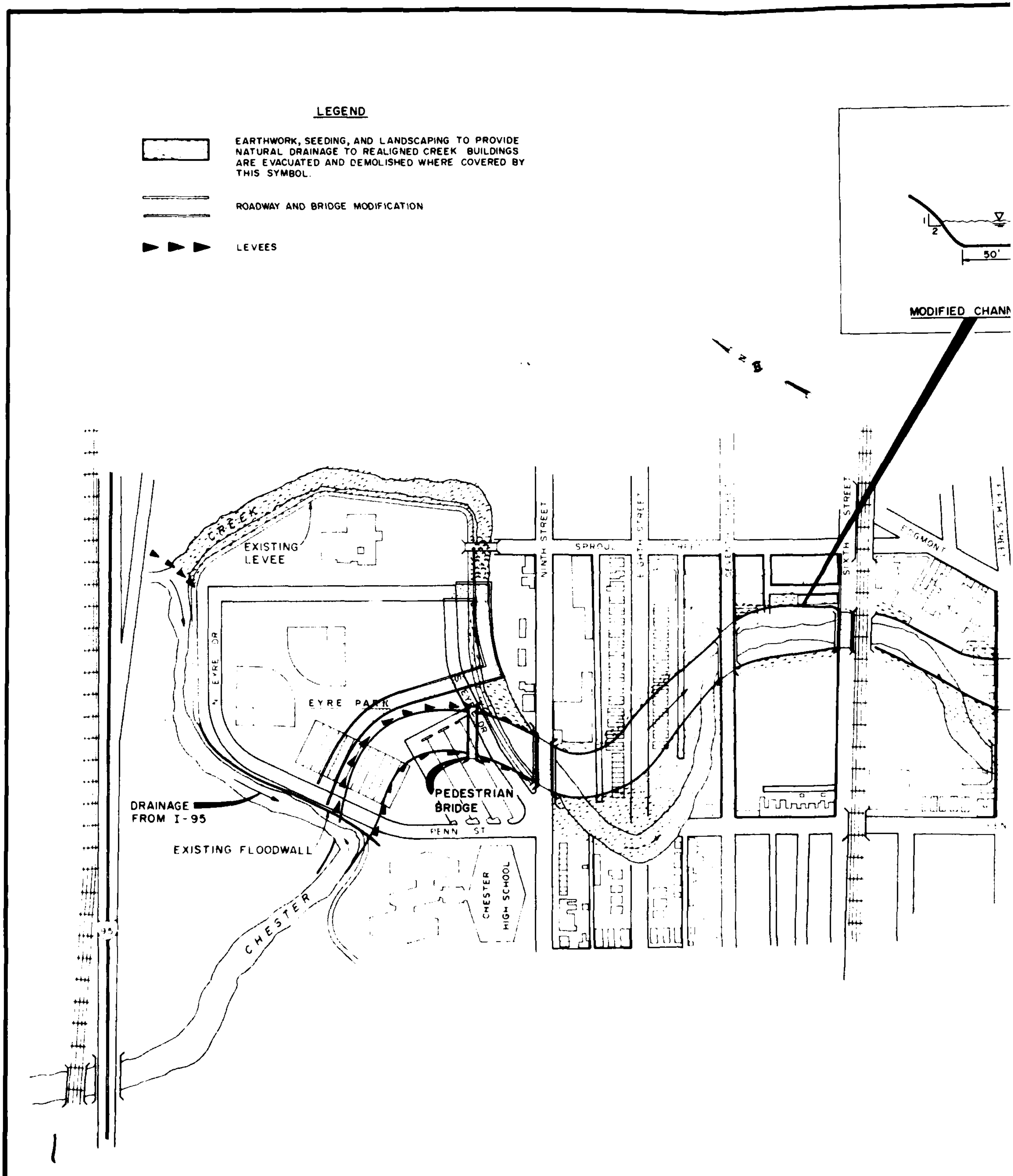

CHESTER CREEK BASIN, PENNSYLVANIA

**CHANNEL REALIGNMENT**
**PLAN S3A**

2

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE 11


LEGEND
EARTHWORK, SEEDING, AND LANDSCAPING TO PROVIDE NATURAL DRAINAGE TO REALIGNED CREEK. BUILDINGS ARE EVACUATED AND DEMOLISHED WHERE COVERED BY THIS SYMBOL.
ROADWAY AND BRIDGE MODIFICATION
LEVEES
50'
MODIFIED CHANN
CREEK
EXISTING LEVEE
EYRE DR
EYRE PARK
PEDESTRIAN BRIDGE
DRAINAGE FROM I-95
EXISTING FLOODWALL
PENN ST
CHESTER
CHESTER HIGH SCHOOL
NINTH STREET
EIGHTH STREET
SEVENTH STREET
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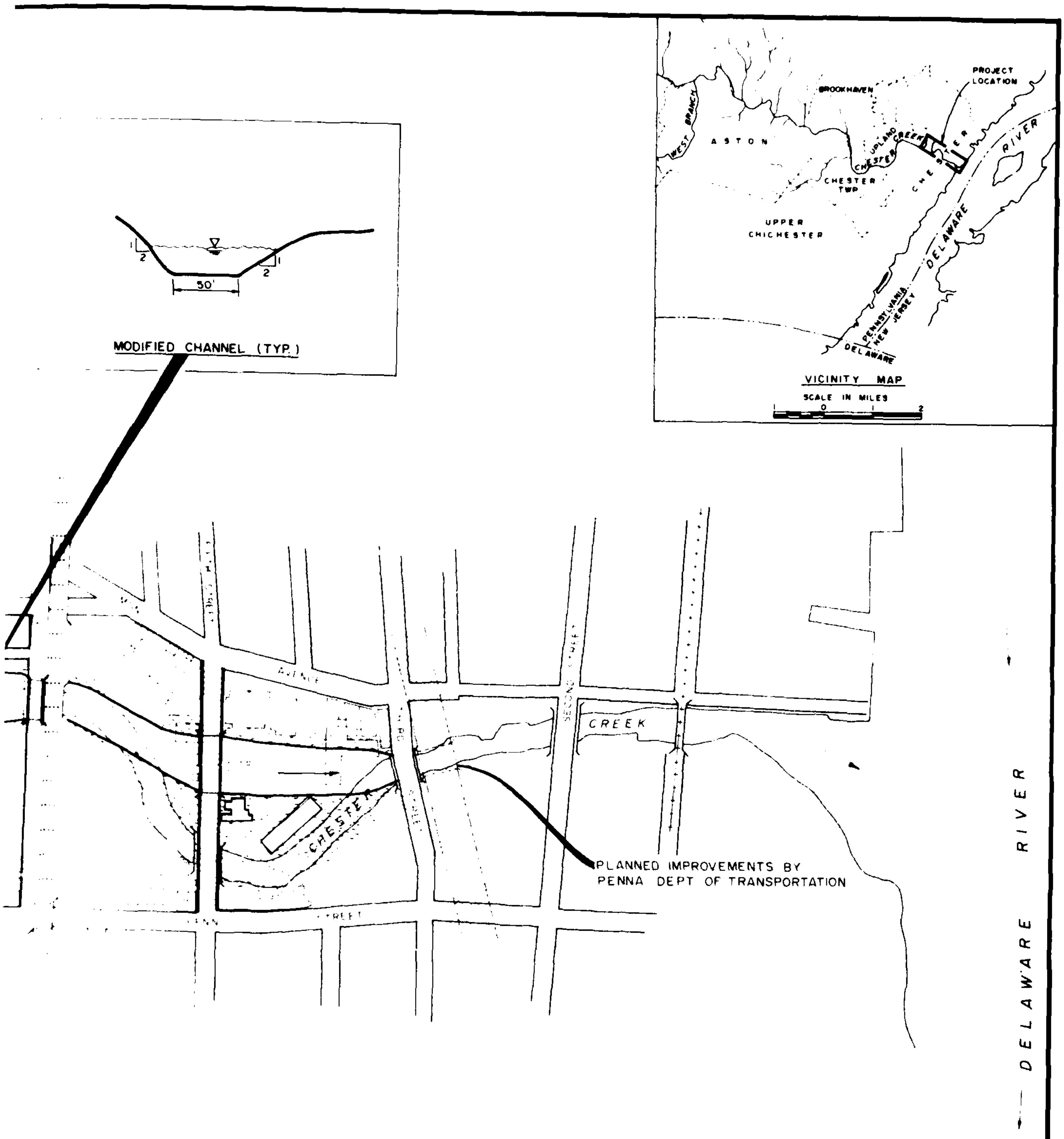
SPROUL STREET
EDGMONT
95




CHESTER CREEK BASIN, PENNSYLVANIA

## CHANNEL REALIGNMENT VARIATION
## PLAN S3Ab

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

PLATE 12

# SUPPLEMENT

METROPOLITAN CHESTER CREEK BASIN
DELAWARE AND CHESTER COUNTIES, PENNSYLVANIA

Information called for by Senate Resolution 148,
85th Congress, adopted 28 January 1958

SUPPLEMENT

SURVEY REPORT FOR FLOOD PROTECTION
METROPOLITAN CHESTER CREEK BASIN
DELAWARE AND CHESTER COUNTIES, PENNSYLVANIA

1. The information in this supplement is furnished in response to Senate Resolution 148, 85th Congress, 1st Session, adopted 28 January 1958. As it would be applied to this study, Senate Resolution 148 calls for data in addition to that presented in the survey report on reasons why alternative flood control plans were rejected, and on effects on State and local governments.

2. More than 47 flood control plans were investigated and evaluated. These involved both structural and non-structural solutions. No plans could be recommended for Federal participation. Most were eliminated because they were not economically justified. Those plans which did indicate potential for economic justification were not supported by local interests. Local interests would not provide the necessary items of local cooperation due to one or more of the following reasons:

- The large amount of property relocations involved;
- The high local costs involved;
- Some local officials felt it was not appropriate that they participate in certain types of plans;
- Some local officials felt they should implement the plans themselves; and
- Some people, who would be protected by a project, simply did not want them because they would be too large in size.

3. Using a 100-year period of analysis for those plans analyzed on a 50-year life does not alter their economic infeasibility. Likewise, future growth in the Basin does not increase benefits sufficiently to justify any plans.

4. Alternative ways of satisfying the non-Federal cost sharing requirements were explored. The Commonwealth of Pennsylvania was contacted to ascertain its ability to contribute toward the non-Federal costs. The Commonwealth responded that it could contribute up to but not more than 50 percent of the non-Federal share of the first costs. With the knowledge that the Commonwealth could contribute a portion of the non-Federal costs, non-Federal interests, both at the county and local level still

concluded that they were not financially capable of participating. Even with an alteration in the cost apportionment between Federal and non-Federal interests, the non-Federal entities would have to then reconsider other non-financial reasons for not supporting these plans.

5. Possible mitigation of adverse aesthetic or social impacts of the plans opposed for these reasons were persued with local citizens. However, they were not satisfied with mitigation measures and still opposed the plans.

6. Due to the conditions described above, it is considered that application of the various standards given in Senate Resolution 148 would not provide a basis for findings substantially different than those reported, and the requirements of Senate Resolution 148 are not applicable.

# [illegible]
# CHESTER CREEK BASIN
# PENNSYLVANIA

## TECHNICAL REPORT

SECTION A - THE STUDY AND REPORT

SECTION B - RESOURCES AND ECONOMY OF THE STUDY AREA

SECTION C - PROBLEMS AND NEEDS

SECTION D - FORMULATING A PLAN

SECTION E - HYDROLOGIC STUDIES

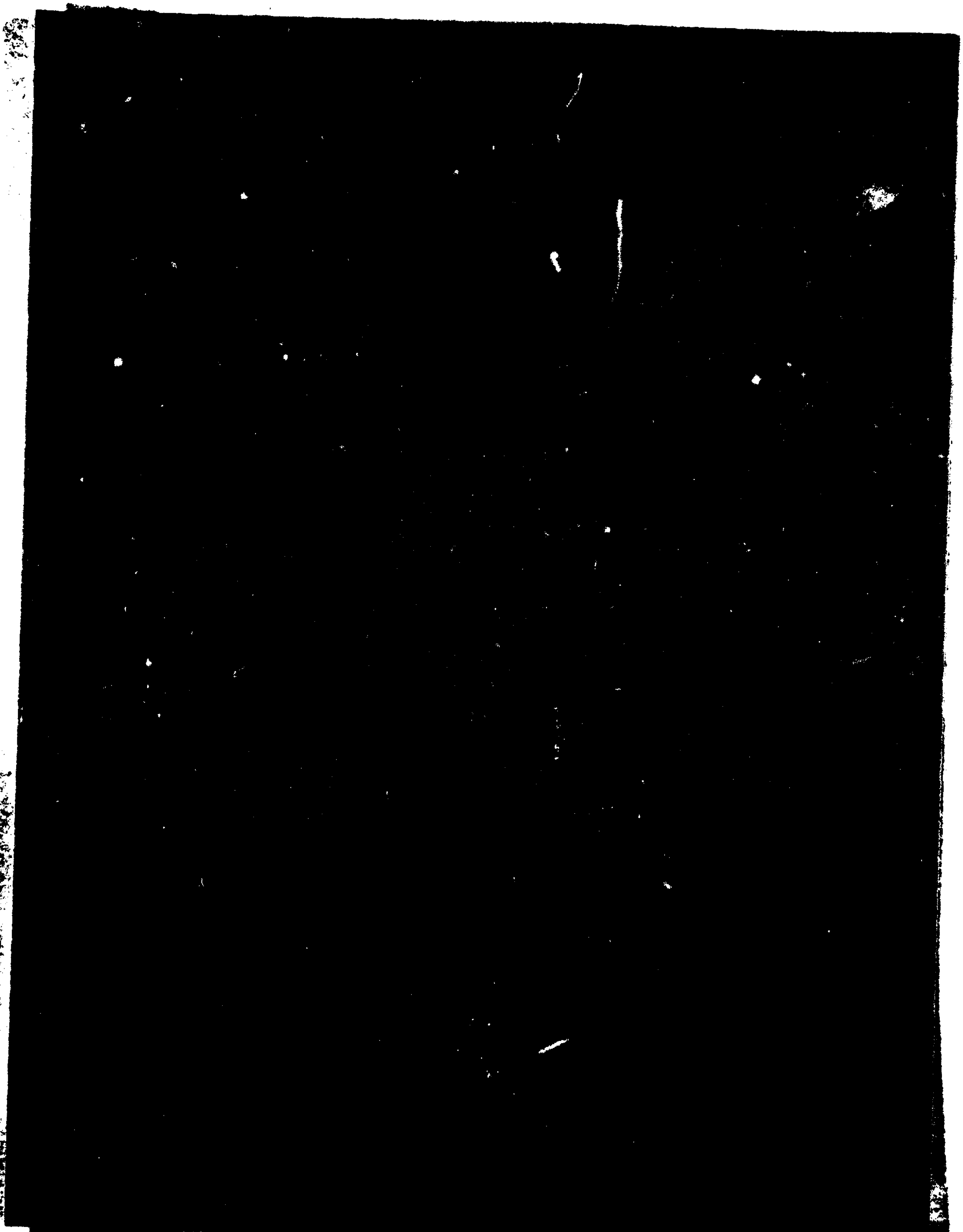
SECTION F - HYDRAULIC STUDIES

SECTION G - [illegible] ANALYSES

SECTION H - ECONOMIC ANALYSES

[illegible]

APPENDIX



SECTION A

# THE STUDY AND REPORT

1. The Chester Creek Basin is located in southeastern Pennsylvania. The Chester Creek is a tributary to the Delaware River. The City of Chester is the major urban center in the Chester Creek Basin.

2. Flooding in the Basin is frequent and results from localized heavy rainfall. This intense rain falling in a relatively long and narrow drainage area with steep side slopes produces flash flooding throughout the Basin. The worst of these floods occurred on 13 September 1971. Over 130 businesses and 732 homes were flooded. Eight lives were lost. This flood control study was initiated as a result of the 1971 flood.

## PURPOSE AND AUTHORITY

3. This Survey Report was prepared in response to Resolutions of the Senate and House of Representatives Committees on Public Works, adopted 2 November and 2 December 1971, respectively.

The Senate Resolution:

> *RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the report of the Chief of Engineers on the Delaware River and Tributaries, New York, New Jersey, Pennsylvania and Delaware, published as House Document Numbered 522, Eighty-seventh Congress, and other pertinent reports, with a view to determing whether any modifications of the recommendations contained therin are advisable at the present time, with particular reference to providing improvements in the interest of flood control, regional water supply and waste water management, water quality control, recreation, and other measures for the enhancement and protection of the environment, in the Chester Creek Watershed in Delaware and Chester Counties, Pennsylvania.*

The House Resolution:

> *RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE HOUSE OF REPRESENTATIVES, UNITED STATES, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports of the Chief of Engineers on the Delaware River and Tributaries, New York, New Jersey, Pennsylvania and Delaware, printed in House Document No. 522, 87th Congress, 2nd Session, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at the present time, with particular reference to providing improvements in the interest of flood control, regional water supply and wastewater management, water quality control, recreation, and other measures for the enhancement and protection of the environment, in the Chester Creek Basin in Delaware and Chester Counties, Pennsylvania.*

4. The purpose of the "Metropolitan Chester Creek Basin Study" is to investigate the flood and related water resources problems and needs of the Chester Creek Basin to develop effective, economical, environmentally and socially acceptable plans for alleviating or reducing these problems, and to determine the extent of Federal participation in implementing a solution.

## SCOPE OF THE STUDY

5. The study was initiated in May 1973 as an Urban Study. During the period from May 1973 to November 1974, Stage I investigations were conducted. This included intense coordination with agencies and interested parties. Stage I was concerned with defining water resources problems and needs of the Basin. Included in these Stage I investigations were preliminary feasibility studies to determine if interim local flood control projects could be provided prior to the completion of the overall Chester Creek Basin Study. These studies centered on the critical flood problem areas which suffered the greatest amount of damage. These were in the lower reaches of the Creek. Only structural flood control plans were investigated. These interim studies indicated that development of flood control projects should not proceed as separate, local interim efforts but as a systematic Basin-wide approach.

6. At the same time that the Chester Creek study was being initiated, the Commonwealth of Pennsylvania was initiating two major efforts, the "State Water Plan" and the "Comprehensive Water Quality Management Plan" (COWAMP). The purpose of these efforts is to develop solutions to the water related problems and needs in the Commonwealth including the Chester Creek Basin. It was the expressed desire of the Commonwealth that the Corps not undertake studies of any water resources problems except flood control. The Chester Creek Study's primary goal was

flood water and flood plain management problems. A secondary goal was to identify any flood control plans which can also be developed for water supply and recreation.

7. The Metropolitan Chester Creek Basin Study was originally part of the Corps of Engineers' Urban Studies Program. As the result of Stage I investigations, the study was eliminated from that Program. All reasonable structural and non-structural plans to solve flooding problems were considered. However, due to the lack of economic justification or local sponsorship, not all plans were investigated at the same level of detail.

8. Numerous field investigations were carried out during the study. Field inspections were conducted during the identification of problems and needs. Additional field trips were made during the plan formulation and evaluation phases of the study. Considerable field work was performed in order to determine the flood damage potential of each damage reach.

9. It was found that stream cross-sections, flood plain topography and soils data was already available and adequate for the study. Consequently, no new survey or boring work was done. Real estate studies were done, including field work. Basin hydrology and hydraulics were modeled using computer techniques.

10. Investigations of the flood control plans were carried through several planning cycles. In each successive cycle fewer plans were considered but the level of detail was increased. Each plan underwent this process until it reached the point where it was shown to be economically unjustified, not implementable by the Federal Government, or not supported by any non-federal government.

## STUDY PARTICIPANTS AND COORDINATION

11. The Corps of Engineers Philadelphia District had the principal responsibility for conducting the study, for formulating and evaluating the flood control plans coordinating the study with other agencies, and preparing the report. When the Study was initiated, a Study Advisory Committee (SAC) was organized to provide direct input into the study effort. SAC members included staff level representatives of the Corps of Engineers, Delaware River Basin Commission, Pennsylvania Department of Environmental Resources, Delaware Valley Regional Planning Commission, Chester County, Delaware County, U.S. Soil Conservation Service and the Bureau of Outdoor Recreation. When the Urban Study was redirected to solely flood water and flood plain management in November 1974, the SAC was discontinued but coordination continued.

12. The study has been coordinated with the appropriate Federal, State, and County agencies, all the municipalities, special interest groups, and the general public. This coordination included meetings, workshops, information bulletins, data sheets, and personnal correspondence. The various agencies consulted and the types of information (other than published reports) provided during the study included:

Soil Conservation Service - topo and survey data; recon reports; file data

Environmental Protection Agency - file data on water quality and discharges into surface waters

U.S. Fish and Wildlife Service - inventory fish and wildlife resources; investigate impacts of plans on fish and wildlife

U.S. Geological Survey - data on stream flow and water quality

U.S. Department of Housing and Urban Development - flood insurance studies and back-up data

Delaware River Basin Commission - water quality and quantity plans

Pennsylvania Department of Environmental Resources - State Water Plan and COWAMP file data; working drafts

Pennsylvania Fish Commission - input into FWS work

Pennsylvania Game Commission - input into FWS work

Pennsylvania Department of Transportation - topo, surveys, plans, subsurface data

Delaware Valley Regional Planning Commission - regional and local population, land use, and economic projections and inventory data

Delaware County Planning Commission - population, land use, and economic projections and inventory data

Chester County Planning Commission - population, land use, and economic projections and inventory data

Basin Municipalities - zoning, inventory file data, mapping, subsurface data.

13. An initial public meeting was held on 19 November 1974 to inform the public of the Stage I findings, to continue with Stage II problem and need identification, and to discuss causes and possible solutions. A Stage II public meeting was held on 27 April 1977 to present the results of the studies of the alternative plans which were considered and to

document public views on these plans. A final public meeting was held on 30 August 1978 to report the study's negative findings that no projects could be recommended for development by the Corps of Engineers. Workshops were used throughout the study primarily for working with municipal representatives and special interest groups. Other public involvement devices which were used extensively throughout the study were newsletters, information bulletins, and data sheets. Eleven issues of the Study newsletter, UPDATE were published. Information Bulletins and data sheets were published. The most widely used device was personal coordination. A more thorough discussion of study coordination and public involvement is presented in Appendix II.

## THE REPORT

14. This report is presented in four parts: the main report and three appendices. The main report is a non-technical presentation of the results of the study. It presents a broad view of the study and findings. Appendix I is a technical report which provides greater detail on the study area; problems and needs; solutions considered; evaluations; and the conduct of the investigations. Appendix I follows the same general outline as the main report. This appendix is the key document for the technical reviewer. Appendix II reports public involvement during the study and contains pertinent cooerespondence relative to the study. Appendix III presents the reports of other agencies regarding this study and report.

## PRIOR AND CURRENT STUDIES

15. There have been many study efforts for satisfying water resources problems and needs in the Chester Creek Basin or the region of which it is a part. These include Federal, State, regional, county and municipal efforts and even some by private interests. A listing and summary of each is presented in the following paragraphs.

16. <u>The Comprehensive Survey of the Water Resources of the Delaware River Basin</u> was completed by the Philadelphia District in December 1960 and subsequently authorized in House Document No. 522 of the 84th Congress, 2nd Session, in August 1962. The report presents a plan for coordinated long range development of the water resources of the Delaware River Basin. Recommendations were made for construction of a number of multi-purpose reservoirs throughout the Basin. No recommendations were made for the Chester Creek Basin.

17. The Philadelphia District prepared a Flood Plain Information Report on Chester Creek, Delaware County, Pennsylvania for the Delaware County Planning Commission in December 1966. It presented information about both past floods in the area and potential future floods along Chester Creek in Delaware County. The data on future floods is no longer up-to-date due to changes in hydrology and hydraulics.

18. The Northeastern United States Water Supply Study (NEWS) was authorized by Congress in October 1965 for assuring adequate water supply for the Northeast's metropolitan centers. The Corps of Engineers was authorized to cooperate with Federal, state, and local agencies in preparing plans to meet long-range water needs. The NEWS study was completed in 1977. No Federal water supply projects were recommended which would affect the Chester Creek Basin.

19. In 1951, the Philadelphia District prepared the Project Report of Flood Control, Chester River, Chester, Pennsylvania. It recommended construction of levees and floodwalls on the right bank of Chester Creek at Eyre Park in the City of Chester. This project was subsequently authorized under Section 205 and constructed by the Corps of Engineers. It was turned over to the City of Chester in April, 1954. The project was overtopped by the 1971 flood, all 216 homes behind the levees and floodwalls were removed, and the area is now in recreational use.

20. In April 1966, the Philadelphia District, prepared a Reconnaissance Report, Flood Problem at Upland, Pennsylvania. This report investigated the flooding problems caused by three small streams; Maris, Lukens and Crozers Runs. No detailed study was conducted due to the finding that the problem was an urban drainage problem, the solution of which was a local responsibility.

21. The National Flood Insurance Program was established by the National Flood Insurance Act of 1968 to make specified amounts of flood insurance available under Federal auspices. The Federal Insurance Administration (FIA) is conducting technical studies through other Federal agencies, state or local agencies, or private engineering firms. These studies are known as Flood Insurance Studies and have been completed in twelve municipalities in the Basin. These studies are underway in six other municipalities. In addition, two Basin municipalities have flood insurance available under the emergency program but have not had any flood insurance studies begun. The only municipality in the Chester Creek Basin which is not participating in either the emergency or regular program is Bethel Township.

22. In 1968 the Delaware Valley Regional Planning Commission (DVRPC) issued the 1985 Regional Land Use Plan which was followed by a Regional Open Space Plan, Regional Plan of Parks and Recreation, Regional Water Supply and Water Pollution Control Plans, and Regional Highway and Mass Transportation Plans. This whole series will be replaced by the Year 2000 Plan which is to be completed by DVRPC in 1978. DVRPC has also

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WATER RESOURCES STUDY FOR METROPOLITAN CHESTER CREEK BASIN, PEN--ETC(U)
SEP 78
UNCLASSIFIED DAEN/NAP-12000/WRS-78/09 NL

2 OF 6
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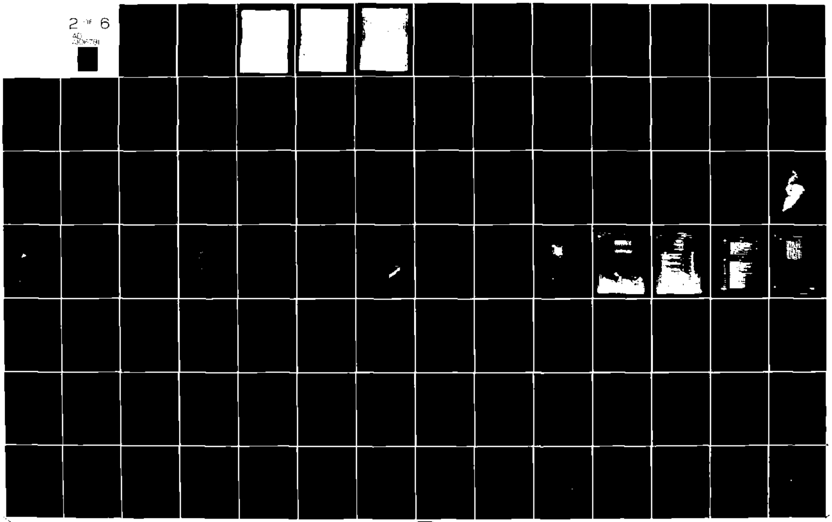


issued regional standards and criteria for stormwater management in a January 1974 report (Standards and Criteria; Regional Standards and Criteria for Stormwater Management).

23. The Pennsylvania Department of Environmental Resources (DER) is to develop a flexible plan for wise management of the water resources to meet present and future needs of the people of Pennsylvania. For the "State Water Plan" planning, Pennsylvania has included the Chester Creek Basin in hydrologic Sub-Basin 3. A draft report on the results of the studies in Sub-Basin 3 was completed by DER in September 1977. The final report is scheduled to be completed in 1978.

24. DER is developing a Comprehensive Water Quality Management Plan (COWAMP). In southeastern Pennsylvania, COWAMP has been combined with the Section 208 Water Quality Management Planning being conducted by DVRPC. The study encompasses municipal and industrial wastewater collection, conveyance, treatment and disposal, abatement of combined sewer and agricultural pollution, maintenance of groundwater quality, and the disposal of sludges and other process by-products. COWAMP/208 issued a report on alternative plans and choices in September 1977 and is scheduled to make its final recommendations to the Governor of Pennsylvania in mid-1978.

25. DER studied the flooding problem at Lenni in Middletown and Aston Townships and issued a report entitled Flood Protection Project, Planning Report in February 1968. The report recommended construction of a levee and channel modification project at Lenni. The project, however, was never constructed.

26. DER studied the drainage problems at the Borough of Upland in 1968-1969. The study recommended construction of a storm sewer system in Maris, Lukens and Crozers Runs at a 25-year capacity. The project was completed in the fall of 1976. Concrete pipes now carry these streams to the Chester Creek. However, this has not solved potential coincident flooding of these tributaries with backwater from the Chester Creek.

27. DER conducted a stream improvement study of Chester Creek near Lenni Road in Chester Heights Borough and Aston and Middletown Townships. This study was conducted in the fall of 1975. A project was constructed during the summer of 1976. This project consisted of removing excess sediment, debris and other deposits, filling in a low lying back channel, installation of a rock deflector and protection of stream banks with rip rap. The purpose of this project was to improve flow conditions under and near the Lenni Road Bridge and reduce minor local flood damages.

28. The Chester County Planning Commission issued a report entitled Natural Environment and Planning in July 1963. Its purpose was to help adjust development to the natural environment. This report presents information for Chester County, which includes the upper portion of the Chester Creek Basin. It presents information on the landforms, geology, soils, woodlands, and climate including maps.

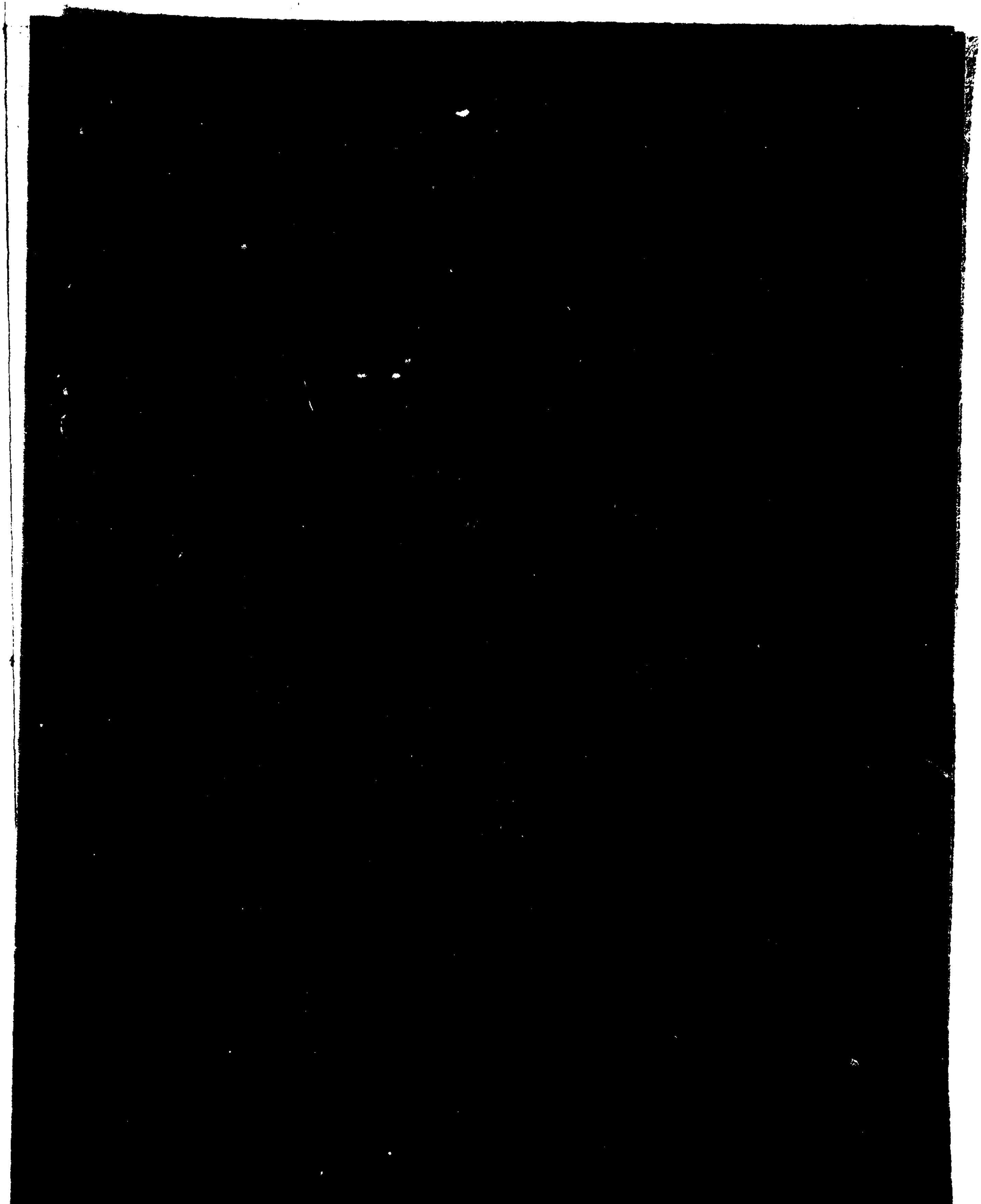
29. A report entitled Water Resources of Chester County, Evaluation of Potential Safe Yield Related to the Projected Water Needs was prepared for the Chester County Board of Commissioners by Geo-Technical Services Consulting Engineers and Geologists in December 1969. The report was prepared to indicate the relationship between the projected water needs and the availability of sources of supply in the entire County including the upper portion of the Chester Creek Basin. Results are presented for three development phases - 1969, 1985, and 2000.

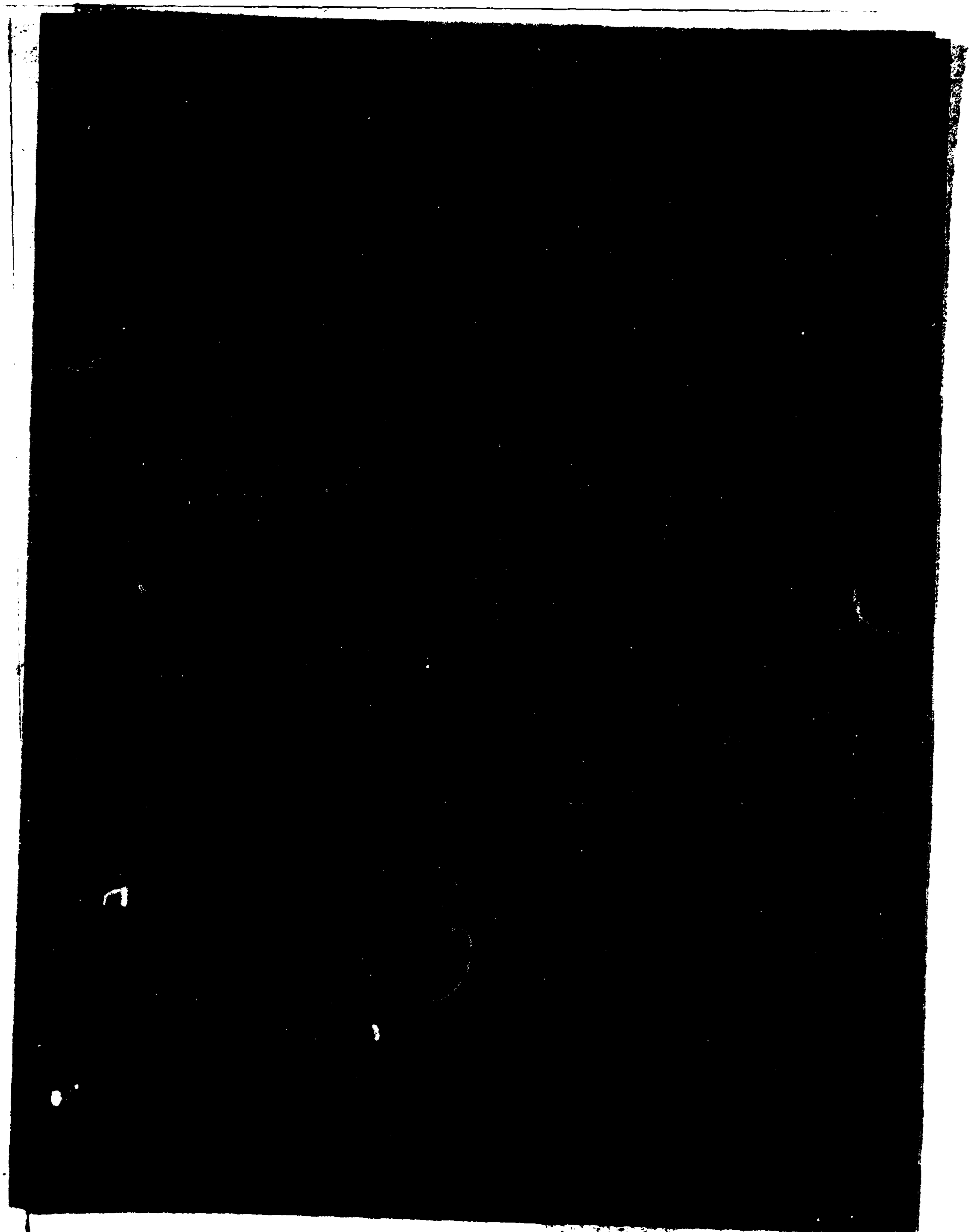
30. Betz Environmental Engineers, Inc. did the Delaware County Regional Sewerage Project for Delaware County. The three volume report issued in November 1972 projected sewerage needs and layed out a plan for providing for those needs. The entire Chester Creek Basin is included. The Delaware County Regional Authority (DELCORA) was set up to implement the plans. Some have been implemented and others are under review as part of the COWAMP/208 effort.

31. In September 1972, G. D. Houtman and Son Civil Engineers prepared a Drainage Study of Goose Creek for the Borough of West Chester. This report analyzes the drainage problem in the Goose Creek watershed and suggests improvements which the Borough of West Chester should make in the drainage system to alleviate the problem. None of these suggestions were ever carried out.

32. Another storm drainage study in the Goose Creek watershed was done for the local businesses and industries in West Chester. The study was conducted by Smith, Chatman-Royce Associates in 1972. It investigated Goose Creek and East Branch Goose Creek to determine the causes of the flooding problems. The report recommended a solution and estimated the costs. None of the recommendations made by either firm were ever carried out.

33. The Soil Conservation Service conducted a reconnaissance in 1972 to determine the feasibility of a P.L. - 566 flood prevention project on Chester Creek, and a staff report was made. Preliminary data which was developed was used in the initial siting of reservoirs in the Chester Creek Basin Study.





SECTION B

# RESOURCES AND ECONOMY OF THE STUDY AREA

1. This section provides the reader with an understanding of the environmental, natural, and human resources of the study area, its development and economy, and trends. Its purpose is to provide a frame of reference for subsequent discussions of problems and needs and of alternative solutions and their effects.

2. This section is based in part on the "Environmental, Social, and Economic Profile for the Chester Creek Basin," dated April 1976 and prepared for this study. It is also based in part on a report of fish and wildlife resources which was prepared by the U.S. Fish and Wildlife Service, State College, Pennsylvania Field Office, in November 1975.

3. The Chester Creek Basin is located entirely within the southeastern portion of the Commonwealth of Pennsylvania as shown on Plate B-1. Chester Creek is a tributary of the Delaware River. The Creek makes its confluence with the Delaware River at the City of Chester. The Basin is located within the suburbs of Philadelphia and within its Standard Metropolitan Statistical Area (SMSA). The Basin lies within the Delaware Valley Region. The Delaware Valley Region as it is viewed for regional planning purposes encompasses the entire SMSA's of the Cities of Philadelphia and Trenton. The region basically radiates from Philadelphia and includes five counties in Pennsylvania and four in New Jersey.

4. The Chester Creek Basin (67.9 square miles) lies within Chester (22 square miles) and Delaware (45.9 square miles) Counties. There are 21 municipalities (city, borough, or township) which are either totally or partially in the Chester Creek Basin. These municipalities are listed and located on Plate B-2. The major urban centers are the City of Chester and the Borough of Upland in Delaware County, and a portion of the Borough of West Chester in Chester County.

# ENVIRONMENTAL SETTING AND NATURAL RESOURCES

5. This sub-section presents information on the environmental setting and natural resources of the Chester Creek Basin. Subjects included are physiography, geology, and minerals, soils, climatology, ground and surface waters, flora, fauna, and open spaces.

## PHYSIOGRAPHY

6. Chester Creek Basin tributaries originate in the Piedmont Upland province of the Appalachian Highlands. The area is characterized by gently rolling countryside with occasional low hills and ridges which run in a northeast to southwest direction. The streams generally run at right angles to the ridges as they flow in a southeasterly direction to the Atlantic Coastal Plains.

7. The Piedmont Province has undergone prolonged erosion resulting in much of its former plateau-like appearance being modified to slopes and gently rounded hills. Erosion has also affected the Coastal Plain Province where beds of unconsolidated or poorly consolidated sediments have been largely removed down through the ages. Except in areas immediately adjacent to the Delaware River, this Coastal Plain consists of a series of isolated fragments separated by streams which have eroded down to the underlying crystalline rocks. In the Basin, only a portion of the City of Chester falls within the Coastal Plain Province. As shown on Plate B-3, a fall line running perpendicular to Chester Creek separates the two provinces.

## SOILS

8. The study area is comprised of four basic soil associations as shown on Plate B-4. Of these the Glenelg-Manor-Chester Association covers approximately 75 percent of the Basin's area. Basic characteristics of these associations follow:

> Glenelg-Manor-Chester Association - The Glenelg soils are similar to Chester soils but are shallower over parent material. The Chester soils are deep and well drained; have a surface layer of dark brown silt-loam; and a subsoil of strong brown light silty clay loam or silt material. The Manor soils are shallow to partly weathered schist and well drained. The sloping soils are likely to erode and require protection.

Neshaminy-Glenelg Association - These soils are gently sloping to steep but mainly moderately sloping. The areas of steep and stony soils are not extensive and mostly wooded. Both the Neshaminy and Glenelg soils are deep to moderaterly deep and well drained. Their substratum consists mostly of weathered gabbro and granodiorite. The channery nature of these soils retards erosion.

Neshaminy-Chrome-Conowingo Association - These soils vary from nearly level to very steep but they are dominantly moderately sloping. The steep and very steep areas are wooded and consist mostly of Chrome soils. Chrome soils have a dary grayish-brown--silty surface layer and a dark-yellowish-brown-clayey subsoil. The Conowingo soils are deep and have mottling in the lower part of the subsoil.

Beltsville-Sassafras-Butlertown Association - These soils are nearly level to moderately sloping but they are mostly gently sloping. The Beltsville soils are deep moderately well drained and have a fragipan. The Sassafras soils are fairly sandy and well drained. The Butlertown soils are moderately well drained.

## GEOLOGY AND MINERALS

9. Most of the Chester Creek Basin is underlain by metamorphic rock formations which have evolved from older igneous rocks. This type of metamorphic rock is created by the recrystallization of molten material deep below the earth's crust in previous geologic ages. The major metamorphic rocks in the Basin consist of schists and gneisses. Smaller amounts of non-metamorphic rocks such as gabbro, quartzite and limestone can also be found. Gneisses are hard, crystalline rocks with a high resistance to erosion while the schists are only moderately hard and tend to weather deeper. Coastal plain sediments underlie the southeastern portion of the Basin near Chester. These deposits consist of sand, silt and clay laid down in varying proportions with sand and gravel beneath. These materials yield easily to erosion. Plate B-3 shows the generalized geology within the Basin and a description of the primary characteristics of these formation follows:

Baltimore Gneiss: Is the basement formation. It is a medium grained crystalline agregate of quartz, feldspar, hornblende and mica. It is sedimentary in origin and generally intruded by gneiss of igneous origin.

Oligocase-Mica Schist: It is finely plicated, medium-granined rock composed of biotite, muscovite and quartz as its princible minerals. Pryite and other iron sulfides are reduced to hydrated oxides which stain these rocks yellow.

Granite and Granite Gneiss: Generally classified as being medium to coarse grained, sometime gneissoid and characteristically prophyritic. Large crystals are light flesh colored orthoclase and range from a half inch to one and one quarter inches in length. The chief constituents of these rocks are quartz, feldspar, biotite and hornblende.

Gabbroic Gneiss and Gabbro: A medium grained massive rock; depending on the amount of ferro-magnesium present, ranges in color from bronz to a greenish gray. Gabbro is usually recognized by rust-colored boulders lying exposed in the fields. In many places the gabbro has also intruded the Baltimore gneiss.

Hornblende Gneiss: Found mainly in the form of dikes and generally connected with larger intrusive masses of gabbro, and in other cases by concealed connectors varies in width from 100 feet to a half-a-mile. Prevailing mineral is hornblende with some feldspar and secondary quartz also present. Primary rock color ranges from dark green to greenish black.

Serpentine: Closely associated with the gabbro are pyroxenite and peridotite that have been altered to serpentine. Massive outcrops occur from the Delaware River into Chester County. Serpentine ranges in color from buff to a deep emerald green or from a light green to a dark blue green with associated shades of reddish brown. Generally have a greenish hue and frequently an oily appearance. Serpentine is basically a hydrous silicate of magnesium, but combines with any number of associated minerals.

Pennsauken Formation: (Also known as Wicomico). It is immediately below the underland terraces and ranges in depth from 60 to 120 feet above sea level. Consists of sand, gravel, boulders, clay loam and some lignitic material. Character of these deposits changes rapidly interchanging between clay and sand while in others the material is poorly assorted. Formation tends to form broad terraces ranging in width up to three miles and roughly paralleling the Delaware River. It occurs as a thin band in the southeastern portion of the study area.

Cape May: (Also known as Talbot). Formation occurs as a terrace rising from the level of the Delaware River to a height of about 40 feet above this stream, with some wave cut cliffs 8-10 feet high being developed in some areas. Consists of sand, clay, gravel, boulders, and peat. These materials are relatively fresh, showing little evidence of disintegration and rarely exceed 15 feet in thickness.

10. There are no significant deposits of metallic ores in Delaware County although chromium and copper have been worked in the past. The County's significant mineral wealth lies in its non-metallic resources and these include clay, sand and gravel, the pegmatite minerals and

stone products. From the rocks of Chester County have come ores of iron, copper, lead, and zinc as well as numerous non-metallic minerals. Two mineral extraction sites and one abandoned quarry lie within the Basin. The two extraction sites are sources of gneiss, granite, agrillite, etc. These are shown on Plate B-3.

## CLIMATOLOGY

11. The study area is within the temperate zone and its climate is continental. Winters are generally mild with little snow. Summers are usually hot and humid, but are occassionally dry resulting in drought. Winter storms are often caused by low pressure areas traversing the Atlantic Coast resulting in heavy rains. Occasionally cold fronts from the west and the Great Lakes will cause heavy rains. During the summer, rainfall is usually caused by the eastward movement of weather fronts. However, on occasion a tropical storm may cause severe rainfall by picking up moisture from the Atlantic Ocean.

12. Precipitation is evenly distributed throughout the year. The normal annual precipitation is about 42.9 inches with the minimum annual precipitation of 29.3 inches recorded in 1922, and the maximum annual precipitation of 55.3 inches recorded in 1873. Approximately 48 percent of the annual precipitation occurs during the period from May through September. The maximum 24 hour precipitation was 5.45 inches during the period 11-13 September 1960. The normal annual snowfall totals about 22 inches. Flooding in the Chester Creek Basin frequently results from localized heavy rainfall. This intense rain, falling in the relatively long and narrow drainage area with steep side slopes, produces flash flooding.

13. The Chester Creek Basin experiences a moderately mild winter with temperatures averaging about 33°F. Summer temperatures average about 76°F. Temperatures vary from day to day throughout the year more so in the winter than the summer. Excessively high or low temperatures as well as prolonged periods of either hot or cold weather are relatively infrequent. Average hourly temperature data from the U.S. Weather Station at Philadelphia indicates that about 4 percent of the year the temperature is over 85°F and that 4 percent of the year the temperature is below 25°F. Sixty-three percent of the year the temperature is between 45°F and 85°F.

14. Like most areas in Pennsylvania, the region's prevailing winter winds are from the northwest and from the southwest during the summer period. Further, the region is upwind from major air pollution sources, and because of wind direction and basic land form, can be considered to be well ventilated. However, some air pollution may occur in the fall during prolonged periods of temperature inversions and low winds, permitting smog accumulation throughout the valley.

## GROUND AND SURFACE WATERS

15. GROUNDWATER AND RELATED GEOLOGY. Groundwater is one of the most important natural resources found in the Chester Creek Basin. The Chester County portion of the Basin is underlain by limestones and shales of the Cambrian and Ordovician Age. The lower portion of the Basin in Delaware County is densely urbanized and surface water systems supply these areas. The water companies largely depend on surface streams and reservoirs supplies requiring filtration and chlorination prior to distribution. Delaware County geological formations do not characteristically provide water supplies to the same extent as those within the Chester County portion of the Basin.

16. Based on Driller's Log Data submitted to the Pennsylvania Department of Environmental Resources between 1965 and 1971, 53 wells were drilled in the Delaware County portion of the Basin and 136 in the Chester County portion. Eleven of these are for industrial use and the rest for private domestic. Average yields are in the 10 to 20 gpm range with depths of 100 to 200 feet and drawdowns of 50 to 100 feet. The well data indicates the basic groundwater formations are found to exist within two producing formations, the Grabbroic Gneiss and Gabbro to be found in both Chester and Delaware Counties and the Oligoclase Mica Schist which is the dominate producing formation within the Chester County portion of the study area. This data does not represent all presently active wells within the Chester Creek Basin, but it does summarize the extent of recent activity and in what aquifers successful results have occurred.

17. Two critical aquifer recharge areas were identified in the COWAMP/208 draft report. The upstream area consists of the eastern two thirds of West Whiteland Township and the northeastern and northwestern quadrants of West and East Goshen Townships, respectively. The downstream area encompasses all of the City of Chester and the southern half of Chester Township.

18. SURFACE WATER. The Chester Creek Basin is drained by main stem Chester Creek and its tributaries as shown in Plate B-2. The East and West Branches are the largest tributaries. There is only one USGS stream gaging station in the Chester Creek Basin. It is located on Chester Creek just downstream from Dutton Mill Road in Brookhaven Borough and has a drainage area of 61.1 square miles. Gage records go back to 1931. The average flow over the period of record has been 83.1 cubic feet per second (cfs). The minimum recorded flow was only 0.3 cfs. The worst flood recorded by the gage was on 13 September 1971 when the flow peaked to 21,000 cfs. The second worst flood was on 25 November 1950 and produced 14,400 cfs. Both caused considerable flooding of low lying areas.

19. Fourteen dams and reservoirs are known to be located in the Basin. Their locations are shown on Plate B-5 and their descriptions and other pertinent data are listed in Table B-1. This is not an extensive inventory. This only includes only those dams in existence for which a Pennsylvania (Water and Power Resources Board) permit was issued.

20. WATER QUALITY. There are eight Pennsylvania Department of Environmental Resources surface water quality sampling stations located in the Basin. Locations are shown on Plate B-6. The reaches for which these stations are used are delineated on the plate. Surface water of the Basin falls within the jurisdiction of two agencies: Pennsylvania Department of Environmental Resources and the Delaware River Basin Commission.

21. All portions of Chester Creek which are protected by the State of Pennsylvania Department of Environmental Resources have established criteria for the area under Title 25, Rules and Regulations, Chapter 93 Water Quality headwaters criteria. The specific water quality criteria for ph, dissolved oxygen, iron, dissolved solids, bacteria, and temperature for Chester Creek from its source to the Dutton Mills Road Bridge, including tributaries are shown on Table B-2. Other parameters such as alkalinity, chlorides, turbidity, odor, etc. are not of sufficient magnitude in this area to require constant monitoring.

22. Water quality criteria depend on intended uses. The Chester Creek Basin waters are generally protected for the following uses:

| | | |
|---|---|---|
| Aquatic Life | - | Warm water fish<br>Trout (stocking only) |
| Water Supply | - | Domestic<br>Industrial<br>Livestock<br>Wildlife<br>Irrigation |
| Recreation | - | Fishing<br>Water contact sports<br>Natural |
| Other | - | Power<br>Treated Waste Assimilation |

From the Dutton Mill Road Bridge to the head of the tidal portion of Chester Creek the criteria are essentially the same except for dissolved oxygen which has a minimum daily average limited of 5.0 mg/l with no value less than 4.0 mg/l. Water is protected for everything listed above except for trout stocking.

23. Table B-2 presents the data found for the 8 reaches on Plate B-6. This data is a summary of data collected in a low flow stream survey in September 1976. In general, water quality within the Chester Creek Basin appears to be good. Iron measured at U.S. Environmental Protection

TABLE B-1
DAMS AND RESERVOIRS
CHESTER CREEK BASIN 1/

| Permit Number | Drainage Area Sq. Miles | Surface Area Acres | Storage Volume Million Gallons | Dam Height Feet | Type 2/ | Dam Code Number Use 3/ | Dam Code Number Class 4/ | Name and Location |
|---|---|---|---|---|---|---|---|---|
| 15-29 | 6.4 | 13 | 5/ | 7 | 2 | 2 | 4 | Westtown-School Lake-East Branch Chester Creek |
| 15-30 | 1.1 | 14 | 10 | 13 | 1 | 24 | 4 | Unnamed Dam-Trib. East Branch Chester Creek |
| 15-146 | 6.6 | 12 | 22 | 21 | 1 | 1 | 3 | Milltown Dam-East Branch Chester Creek |
| 15-266 | 2.9 | 65 | 205 | 34 | 1 | 1 | 2 | Township Line Dam-East Br. Chester Creek-Delaware Co. |
| 23-4 | 56 | 5/ | 2 | 10 | 3 | 8 | 4 | Rockdale Dam-Chester Creek |
| 23-5 | 36.6 | 4 | 5/ | 10 | 6 | 8 | 4 | Cotton Mill Dam Chester Cr. |
| 23-6 | 18.5 | 5/ | 5/ | 12 | 6 | 8 | 4 | Plant #3 W. Br. Chester Cr. |
| 23-10 | 36.2 | 16 | 5/ | 17 | 23 | 8 | 3 | Lenni Dam-Chester Creek |
| 23-11 | 19.0 | 5/ | 5/ | 10 | 6 | 8 | 4 | Unnamed Dam-W. Br. Chester Cr |
| 23-12 | 18.0 | 5/ | 5/ | 20 | 6 | 8 | 3 | Llewellen Mill-West Branch Chester Creek |
| 23-17 | 5.1 | 5/ | 5/ | 6 | 6 | 8 | 4 | Concord Mills-W. Branch Chester Creek |
| 23-33 | 32.6 | 8 | 8 | 12 | 6 | 8 | 4 | Unnamed Dam-E. Branch Chester Creek |
| 23-87 | 1.4 | 5/ | 5/ | 10 | 12 | 1 | 4 | Unnamed Dam-Concord Creek |
| 23-70 | 1.6 | 9 | 5 | 5 | 23 | 2 | 4 | Brinton Lake Dam-W. Branch Chester Creek |

1/ Source: Water Resources Bulletin #5 Penna. Dept. of Forest and Waters 1970. Note that only those dams and reservoirs receiving State Permits are included in this table.

2/ Type of Dam -
1. earth
2. masonry (any type)
3. concrete (gravity)
6. rockfill

3/ Use of Dam -
1. public water supply
2. Recreation, pleasure, fish propogation, landscaping, etc.
4. electric power generation (stream and/or hydroelectric)
8. water power - mechanical (not including hydroelectric)

4/ Dam Classification -
2. dam with intermediate flood hazard potential should it fail (property damage but probably no loss of life)
3. dam with low flood hazard potential should it fail (property damage only in reach just below the dam)
4. flood hazard potential is essentially non-existent.

5/ Storage Volume Less Than 0.5 M.G. Surface Area Less Than 1/2 Acre.

TABLE B-[illegible]
WATER QUALITY
CHESTER CREEK BASIN 1/

| CRITERIA | WATER QUALITY STANDARD 2/ | REACH 3/ 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| pH | Not less than 6.0, and not more than 8.5 | 6.7-7.6 | 6.8-7.0 | 7.0-7.6 | 7.1-7.6 | 6.5-7.5 | 7.2-7.8 | 7.3-7.8 | 6.8-8.5 |
| Dissolved Oxygen | For the period 2/15 to 7/31 of any year minimum daily average of 6/0 mg/1, no value less than 5/0 mg/1. For the remainder of the year minimum daily average of 5.0 mg/1 no value less than 4.0 mg/1. For the epilimnion of lakes, ponds, and impoundments, minimum daily average of 5.0 mg/1, no value less than 4.0 mg/1. | 4.8-11.5 | 7.0-8.0 | 4.5-10.0 | 5.0-9.3 | 2.5-9.0 | 7.5-10.2 | 6.8-7.2 | 7.0-12.8 |
| Iron | Total iron not more than 1.5 mg/1. | 4/ | 4/ | 4/ | 4/ | 4/ | 4/ | 4/ | 4/ |
| Dissolved Solids | Not more than 500 mg/1 as a monthly average value: not more than 750 mg/1 at any time. | 180-282 | 172-188 | 216-232 | 278-432 | 384-1038 | 114-162 | 148-160 | 160-172 |
| Bacteria | Fecal coliform density in five consecutive samples shall not exceed a geometric mean of 200 per 100 ml. | 470->6000 | >6000 | 280-370 | 160->6000 | 13->6000 | 26-780 | 20-21 | 20-48 |
| Temperature | For the period of 2/15 to 7/31 not more than 3°C rise above ambient temperature or maximum of 23°C whichever is less, not to be changed by more than 1°C for any one hour period; for the remainder of the year, the maximum is raised to 31°C. | 22-25 | 18 | 15-22 | 15-19.5 | 15-23 | 14.5-19 | 15-21 | 14.7-21 |

1/ Data from Chester Creek Pa. Low Flow Stream Survey, 9/76, provided by Delaware Valley Regional Planning Commission.
2/ Pa. Department of Environmental Resources Standards.
3/ See location of reaches on Plate B-6.
4/ Data not available. Tests not conducted.

Agency (EPA) monitoring station in reach 4 has hit peaks of 7.2 mg/l, but the average from 1946 to 1974 is 1.212 mg/l. This is within State standards. Samples taken in 1973 and 1974 show a significant decrease with an average of 0.844 mg/l. The same improvement is also occurring with pH and dissolved solids. The one reach which seems to have very serious water quality problems is Reach 5, Goose Creek, with dissolved oxygen, dissolved solids, and bacteria failing to meet standards.

24. Only Reach 1 is also protected by the jurisdiction of the Delaware River Basin Commission. Commission regulations, Part III, Basin Regulations - Water Quality, are for interstate rivers which include the Delaware River and the associated tidal portions of adjoining tributaries. This includes approximately the first 1-2 miles of Chester Creek. EPA has monitored water quality in the Chester Creek in the City of Chester. Data indicate that most criteria are within Commission requirements. Only threshold-odor exceeds the standards. Testing has not been done long enough to determine if the problem is improving or not. Fecal coliform data is not conclusive.

## FLORA

25. The natural cover of the area is hardwood forests. The forests are made up of deciduous hardwood types such as red and black Oaks, Tulip Poplar, Beech, Chestnut Oak, Virginia Pine and Pitch Pine. The remainder of the area is either used for farming, open pastures, or urban uses. There are no Federal or State forest lands in the Basin.

26. In 1968 the U.S. Forest Service published a comprehensive state inventory listing type, quality, and quantity of timber resources. This Forest Service study divided Pennsylvania into six geographic units with Delaware and Chester Counties located in the southeastern-twelve-county unit. This survey included lands at least 10 percent stocked with trees capable of producing timber and wood products or of exerting an influence on the climate or water regime. Excluded from this survey were forested tracts less than one acre, isolated strips of timber less than 120 feet wide, and abandoned fields not yet 10 percent stocked with trees. Based on this survey timber resources within the southeastern geographic unit lost 4% in acreage from 1955 to 1965. It was the only unit within the state to lose timber acreage. This loss is not surprising when compared to the rate of urbanization that has occurred during this period, especially within the Philadelphia SMSA. This loss, if continued, could have a potential impact on watershed management within the region. A summary of the survey is shown in the following:

| | Total Land Area | Nonforest Land Area | Forest Land Area Non-Commercial | Forest Land Area Commercial |
|---|---|---|---|---|
| | in thousand acres | | | |
| Chester County | 486.4 | 368.3 | 1.3 | 116.8 |
| Delaware County | 118.4 | 118.4 | — | — |
| Total (12 County Area) | 3,938.0 | 2,980.0 | 24.0 | 934.0 |
| Total (State) | 28,804.5 | 11,732.4 | 354.2 | 16,717.9 |

Based on this inventory, Delaware County has **no** forested areas, while Chester County's ratio of non-forested lands to total land area is 75.7%. Of those timber resources which are in the region, only a small portion are in the Chester Creek Basin. The portion of Chester County which is in the Basin is more urbanized than the remainder of the County. As a result, the ratio of non-forested land to total land area in the Basin is greater than the County's 75.7%.

27. The basic tree cover is predominantly hardwood types. These hardwood stands represent second and third growth timber. An approximate distribution of trees is as follows:

| Type | Percent of Total |
|---|---|
| Pitch-virginia pine | 1 |
| Oak-hickory | 67 |
| Other oak types | 2 |
| Elm-ash-red-maple | 15 |
| Maple-beech-birch | 13 |
| Aspen-birch | 2 |
| Total | 100 |

28. From the standpoint of ecological importance, the only significant vegetation in the Basin is a marsh located along Chester Creek in Cheyney, Pennsylvania discussed in the fauna section. The major value of the remaining woodlands are their aesthetic or recreational potential. Most of the woodlands are in private ownership, and their useage by the public, particularly for recreation, is limited. The majority of significant woodland acreage remaining in the Basin is along the streams or on steeper sloped areas. The total woodlands and tree cover within the Basin is extensive as indicated below.

| | Tree Coverage | Orchards & Nurseries | Total | Percent of Basin |
|---|---|---|---|---|
| Chester County | 2.5 | 0.4 | 2.8 | 4 |
| Delaware County | 8.3 | 1.0 | 9.4 | 14 |
| TOTAL | 10.8 | 1.4 | 12.2 | 18 |

29. Most of the acreage is in small isolated parcels. While orchards and nurseries are important to the overall agricultural activity for each county, these are not an extensive portion of the Basin's tree coverage.

## FAUNA

30. Wildlife in the area is varied and typical of northeastern United States. Wildlife is slowly becoming more concentrated and is slowly migrating away from the urbanizing areas. Because the woodland of the area is scattered throughout the Basin, the wildlife which use the woodlands for protection and cover is also scattered. The number of wildlife species within the Basin is not as extensive as at the turn of the century or even as late as the 1930's because urbanization is reducing or eliminating natural habitats available to indigenous wildlife. Species which cannot adjust to human intrusion, for example the white-tailed deer have moved to the quieter natural areas in the upper portion of the Basin. Others such as the cottontail rabbit can adapt to a limited suburban development and will remain, but often their numbers will be reduced. Finally, others such as the muskrat, because of extensive changes to their natural habitat, become an infrequently seen species. Changes in the nature cover, loss of wide fence rows, and filling of swamps and marshes have combined to reduce available nesting, protection and feeding grounds.

31. The Department of the Interior publication *Endangered and Threatened Wildlife and Plants, dated 1 July 1977 as printed in the 14 July 1977 Federal Register* has been reviewed. No known threatened or endangered species of fish, reptile, bird, mammal or amphibian is found in the Basin. However, the Basin is included in the general range of the following endangered species: southern bald eagle, American peregrine falcon and shortnose strugeon. The ranges of the American osprey, Ipswich sparrow, and the bog turtle included the study area and are considered rare locally.

32. According to the U.S. Fish and Wildlife (FWS) and literature research, there are no apparent areas of significant ecological importance in the Basin. One Type II marsh is located just north of Cheyney.* The marsh is a low lying meadow which is above water most of the time with the water table within 2 to 3 inches of the ground surface. It is the only area of this nature in the Basin and, therefore, may have some significance out of proportion to its ecological value. Virtually all major vegetation in the Basin is second growth with no indications of any significance.

* FWS describes a Type II marsh as an inland fresh meadow which is waterlogged but has no standing water through most of the growing season.

33. The Basin's fish and wildlife resources are restricted to adaptable species. White-tailed deer is the only big game species in the Basin and does not occur in large numbers. Gray squirrels are common throughout the Basin and are most numerous in mature woodlots. Cottontail rabbits are common along forest edges and around homes with good shrubbery habitats. Ringnecked pheasants, quail, and doves are the three major gamebirds of the area. Fox hunting with horses and hounds is a popular sport in the Basin. Raccoons and muskrats are the most abundant furbearers, although they are more valuable for aesthetics and environmental education than for furs. Opossum, skunk, and weasel also occur but none are extensively harvested.

34. The Basin's waterfowl habitat is limited to ponds, reservoirs, and some stream sections. Hundreds of Canada geese migrate through the area and rest on larger impoundments. Mallards are the predominate duck species though wood ducks and black ducks also occur. Woodcocks are found in the few remaining swampy areas or bogs, such as the area near Cheyney.

35. Fishery resources within the Basin consist of both warmwater and coldwater species. Streams suitable for trout are Chester Creek (11.3 miles), West Branch (7.0 miles), and East Branch (1.2 miles) totaling 19.5 miles. One of the better trout areas runs from near Cheyney to Glen Mills. Warmwater stream fisheries occur throughout the remaining streams, but are limited due to pollution. Principle stream fish species include trout, smallmouth bass, bullhead, sucker, eel, and sunfish. Twelve impoundments, totaling about 150 areas, comprise the impoundment type fisheries. Principle sport fishes produced within the impoundments include largemouth bass, bluegill, crappie, and bullhead. Fishing opportunities are extremely limited in relation to high demands in the area. There is no commercial fishing in the Basin. No anadromous fish use Chester Creek.

## OPEN SPACES

36. The Chester Creek Basin comprises approximately 22 square miles in Chester County and 45.9 square miles in Delaware County. Of this approximately 14 and 36 square miles, respectively, are classified as open spaces. This amount of open space appears to be abnormally high for an urbanized area. Much of the land classified as open is actually utilized as farm land and extremely low density residential. As shown on Plate B-7, much of the open land is devoted to institutional uses. Institutional lands comprise a total area of 5 square miles and rank second only to residential of the Basin's developed uses. Institutional uses represent some 7% of the Basin area; 3% of Chester County Basin area and 9% of Delaware County's. Finally, of the 5 square miles of institutional lands, 1 square mile comprises major cemetery areas as shown on Plate B-7. Small isolated family cemeteries are not inventoried.

# HUMAN RESOURCES

37. This subsection presents information on the characteristics of the people of the Chester Creek Basin. Included is a brief history of the area and its people, population characteristics and projections, labor force data, and information on community facilities, organizations, and schools. There is a fairly large disparity which exists between the older established communities and those that are currently undergoing urbanization. The established communities are undergoing little or no population increase while the developing areas are being subjected to fairly rapid population increases. This affects economic activities, school enrollments, etc.

## HISTORY OF THE PEOPLE

38. Chester County is one of the three original counties established by William Penn in 1682, and originally included Delaware County and most of the territory southwest of the Schuylkill River. The western boundary of Chester County was established by the creation of Lancaster County in 1729 and the north and northwestern by the establishment of Berks County in 1752. Philadelphia County formed the northeastern and eastern boundary, until 1784 when Montgomery was created. The Town of Chester (Upland) was the county seat for all government activity for over a century, but as the county became settled residents began insisting on a more central location, one away from the extreme eastern county boundary. In 1784, the assembly selected a central point near the "Turks Head Tavern" at the intersection of the Great Road leading from Wilmington to Reading and the road from Philadelphia to Strasburg in Lancaster County. In 1788 this new county seat was incorporated into the Borough of West Chester. This made the eastern most county residents resentful and embittered. Actually, they were so provoked that a group of concerned citizens, armed and with field cannon, marched upon the new county buildings. However, at the last minute a direct confrontation was avoided. These differences were resolved in 1790 with the creation of Delaware County from the Eastern Chester County. The reason for the wandering boundary that still exists between the two counties is because freeholders, where the line was to cross, were permitted to select the county in which they wished to be located.

39. As part of the Chester County and then as a separate county, Delaware County is rich in historical events leading to the early development of this Commonwealth. The City of Chester can trace its beginnings to the settlement called Upland established in 1643. William Penn arrived at Upland in the fall of 1682, changed its name to Chester; and

on December 4th, the First Assembly of Pennsylvania was convened at Chester. The Battle of Brandywine, fought on August 11, 1777 west of Chester, lasted all day ending with General Washington's forces withdrawal that night to Chester and subsequent retreat the following day towards Philadelphia.

40. A brief description of the history of municipalities within the Chester Creek Basin area is as follows:

Aston Township: Was organized as a municipal government in 1687 and named after Aston in Berkshire, England. It was at Village Green during the Revolutionary War that General Howe camped for several days during which some Hessian Soldiers, found guilty of marauding the adjoining countryside, were executed.

Bethel Township: Was organized in 1694 and prior to that was part of Concord Township. It's name is derived from the second letter of the Hebrew Alphabet - "Beth", with ending "el" signifying the "House of God." The first township road running between Concord and Chichester was laid out and constructed in 1686.

Birmingham Township: Named for Birmingham, England. It was surveyed in 1684 and was divided when Delaware County was created with an addition to the township from East Bradford made in 1856. The Battle of Brandywine was fought in this township.

City of Chester: Developed from the Village of Upland; changed to Chester in 1682 by William Penn. The oldest municipality in the Commonwealth of Pennsylvania.

Chichester Township: One of the older county settlements. Residents of Marcus Hook petitioned to change the name to Chichester after the city in Sussex, England. In 1722 the original township was divided into Upper and Lower Chichester Townships with the latter containing Marcus Hook, a borough created by William Penn in 1701.

Concord Township: The largest township in the county was organized in 1688 and gets its name from the harmonious feelings among early settlers. The Commonwealth's second paper mill (1729) was located here. Bank notes and papers for the Country including that used for continental currency were made in this mill during the early days of the republic. The first township road between Birmingham and Chester was constructed in 1687.

Edgmont Township: Created as a township in 1687, and named after an area in Shropshire, England. A curious upheaval of rocks, known as Castle Rocks was a tourist attraction at an early date.

Goshen Township: Was included in the original survey for the Welsh but was organized as a township in 1704. In 1818 the township was

divided into East Goshen Township and West Goshen Township. Lands for the creation of West Chester Borough were taken from the township in 1788.

Middletown Township: Named for its central location was organized about 1687. The first Presbyterian Church in Delaware County was organized here.

Thornbury Township: Was named from Thornbury in Gloucestershire, England. The present township represents about one-fourth of its original area because of the creation of Delaware County.

Upland Borough: Was created by the Court of Quarter Sessions on February 22, 1869. The site of the Historic Chester Mills, owned at one time by the John P. Crozier Family. The first grist mill was set up by William Penn in 1683 in Upland and managed by Caleb Pusey.

Westtown Township: Was organized about 1700. Six hundred acres were purchased by the Society of Friends in 1794 where they established the historic Westtown Boarding School.

Whiteland Township: Was organized about 1704. Northwestern part of the original Welsh tract of 40,000 acres, which was laid out in 1684, with the expectation this would be a separate barony where they could manage their own municipal affairs. The township was divided into East Whiteland and West Whiteland Townships in 1765.

41. As testimony to the rich history of the Basin are the 114 sites which are on the State's list of historic sites. This State list includes National Register Sites and National Historic Landmarks. These sites are shown on Plate B-8. As shown on the Plate, nine of the sites are listed in the National Register of Historic Sites.

## PEOPLE OF THE BASIN

42. Delaware and Chester Counties with 1970 populations of 601,715 and 277,746, respectively, are both part of the Philadelphia Standard Metropolitan Statistical Area (SMSA). The City of Chester, the major urban area in the Basin, has experienced a steady decline in the population since the end of World War II. Population, which reached 66,039 in 1950, had declined to 56,331 by 1970. The City is expected to regain some of its population by the year 2000. Most of the remainder of the Basin has had a steady increase in population which is expected to continue in the future.

43. Population data for 1970 and projections for 1980 and 1990 are given in Table B-3. Projections are presented for each municipality. Table B-4 presents, for comparison purposes, State and County level projections

TABLE B-3
POPULATION DISTRIBUTION
CHESTER CREEK BASIN

| | 1970 | 1980 | 1990 |
|---|---|---|---|
| Delaware County | | | |
| Aston Township | 11,511 | 12,762 | 13,876 |
| Bethel Township | 468 | 736 | 1,035 |
| Birmingham Township | 115 | 141 | 175 |
| Brookhaven Borough | 4,925 | 5,180 | 5,339 |
| City of Chester | 10,703 | 10,570 | 10,854 |
| Chester Heights Borough | 1,277 | 1,528 | 1,653 |
| Chester Township | 3,710 | 3,927 | 4,047 |
| Concord Township | 4,361 | 7,410 | 10,450 |
| Edgmont Township | 328 | 696 | 1,056 |
| Middletown Township | 8,628 | 10,921 | 13,400 |
| Parkside Borough | 937 | 937 | 947 |
| Thornbury Township | 2,599 | 2,925 | 3,211 |
| Upland Borough | 3,930 | 3,931 | 4,036 |
| Upper Chichester Township | 81 | 89 | 97 |
| Chester County | | | |
| Birmingham Township | 100 | 162 | 237 |
| East Goshen Township | 1,644 | 2,493 | 3,321 |
| Thornbury Township | 1,163 | 1,627 | 2,169 |
| West Goshen Township | 9,773 | 12,613 | 16,014 |
| West Chester Borough | 5,404 | 5,726 | 6,181 |
| Westtown Township | 3,891 | 5,152 | 6,989 |
| West Whiteland Township | 214 | 275 | 346 |
| TOTAL | 75,762 | 89,801 | 105,433 |

1/ Figures only for portions of each political unit within the basin.

TABLE B-4
POPULATION DISTRIBUTION
CHESTER AND DELAWARE COUNTIES 1/

| County | 1970 | 1980 | 1990 |
|---|---|---|---|
| Pennsylvania State Population | 11,817,000 | 12,319,165 | 13,385,204 |
| % of State Projection | (100%) | (100%) | (100%) |
| Rate of Change | | 4.25% | 8.65% |
| Chester County | | | |
| % of State Projection | (2.36%) | (2.68%) | (3.05%) |
| Rate of Change | | 18.49% | 23.59% |
| Delaware County | | | |
| % of State Population | (5.10%) | (5.07%) | (4.02%) |
| Rate of Change | | 3.61% | 7.63% |

1/ Extracted from: Pennsylvania Projection Series; Population and Labor Force; Office of State Planning & Development, November 1973.

for the same years. Of the 879,461 persons living in the two counties, an estimated 75,762 people (8.6%) live within the Basin.

44. The population characteristics of the Basin are very different from Chester and Delaware Counties as a whole. The white population of Chester and Delaware Counties is about 92% of their total population, with the black population being slightly more than 7% of the total. The Basin profile is entirely different with 75.6% being white, and 24% black. Since the municipalities which lie at least partially in the Basin contain a total of 12.86% of the entire two county population, nearly 42% of the blacks in the two county region are located within the Basin municipalities. Blacks are concentrated in the Basin's older and poorer urban centers. The age group within the Basin also tends to be younger than the median age in Delaware County but more closely approximates that in Chester County. From 1970 Census data:

| | Basin | Chester | Delaware |
|---|---|---|---|
| Total | 26.8 | 27.2 | 29.8 |
| White Male | 27.1 | 27.0 | 28.3 |
| White Female | 29.9 | 28.4 | 32.5 |
| Black Male | 20.3 | 22.4 | 22.7 |
| Black Female | 22.9 | 22.5 | 26.3 |

45. The average population change from 1960 to 1970 for the two counties was 15%. Delaware County's increase of 8.5% was due entirely to increases caused by reproduction, with migration amounting to an exodus of 1.6%. Chester County's reproductive change was slightly higher (12.1%) than Delaware's but in-migration amounted to a 20.0% increase which was second largest migration change in the State.

46. By 1980 the population of the Basin will increase by 18.5%. Chester County's portion of the Basin's population will increase from 29.3 to 31.2 percent. The most rapid growth will occur in the municipalities above the confluence of the East and West Branches of Chester Creek. The two exceptions will be West Chester Borough and Thornbury Township (Delaware County). Below the confluence the municipalities' growth rates will be well below the Basin average with the City of Chester showing a loss. By 1980, the Basin population will contain approximately 10% of Delaware County's population and 8% of Chester County's.

## THE LABOR FORCE

47. The people in the Chester Creek Basin municipalities account for 12.4% of the total labor force in Chester and Delaware Counties. This is very close to the population of the 2 counties that the Basin municipalities comprise. The slight difference can be accounted for by the lower age of the Basin residents, many of whom are not yet old enough to

enter the larbor force. The labor force participation rates compared to the State-wide average are:

| | Both Sexes (percent) | Male (percent) | Female (percent) |
|---|---|---|---|
| Pennsylvania | 56.4 | 75.8 | 39.3 |
| Chester & Delaware (total) | 58.9 | 79.1 | 40.1 |
| Chester Creek Basin | 57.9 | 77.1 | 40.0 |

48. The differences in participation rates between Chester and Delaware Counties and the Basin is due in part to the lower black male participation rate in the Basin as indicated below. The opposite is true of females where the black female participation rate is higher than the white.

| | Male | Female |
|---|---|---|
| Total | 77.1 | 40.0 |
| White | 78.1 | 39.0 |
| Black | 73.1 | 44.9 |

## COMMUNITY COHESION

49. Four cultural facilities are located in the Basin. They are the Delaware County Historical Society and the Deshong Art Museum in the City of Chester, and the Chester County Historical Society and Project 1776 in West Chester. The major libraries in the Basin are the J. Lewis Crozer Library (2 branches) and the Widener College Library in Chester, the Cheyney State College Library in Cheyney, and the Chester County Library and West Chester Public Library in West Chester. There are fifteen different religious denominations with thirty-five facilities in the Basin distributed as shown below:

| Type | Number of Churches |
|---|---|
| African Methodist Episcopal | 1 |
| Alliance | 1 |
| Baptist | 9 |
| Catholic | 2 |
| Christian & Missionary | 1 |
| Christian Science | 1 |
| Church of Christ | 1 |
| Community | 1 |
| Episcopal | 2 |
| Independent Fundamental | 1 |
| Lutheran | 2 |
| Salavation Army | 2 |
| Seventy-Day Adventist | 1 |
| Ukranian Catholic | 1 |
| United Methodist | 6 |
| United Presbyterian | 3 |

50. A listing of clubs, associations, and organizations is shown below. Many of these groups are located in the areas of higher population density, particularly West Chester and Chester.

American Legion Post #134 - West Chester
Boy Scouts of America - West Chester
Brandywine Grange #60 - West Chester
Brandywine Valley Association - West Chester
Delaware County Community Action Center - Chester City
Delaware County Field & Stream Association - Chester City
Delaware County Historical Society - Chester City
East End Sportsmen's Club - Chester City
Eastern Light Lodge #46 - Chester City
Elk's Lodge - Chester City
Girl Scouts of Delaware County - Chester City
Green Ridge Recreation Club - Green Ridge
Knights of Columbus Americus Council 242 - Chester City
Knights of Columbus - West Chester
Loyal Order of Moose - Chester City
Marine Corps League - Upland
Masonic Temple of Chester - Chester City
Miles Killen Post 87 - American Legion - Aston
Polish American Eagle Citizens Club - Chester City
Rod & Gun Club - Chester City
Spanish Civil Club - Chester City
St. Hedwigs Catholic Club - Chester City
Szymanski & Rywacki Vet. Association - Chester City
Ukranian Catholic American Cit. Soc. - Chester City
West End Boat Club - Chester City
Young Men's Republican Club - Chester City

51. Table B-5 describes the length of time an owner/renter has occupied a specific residence. Discussions with both County and local officials confirm that the Basin has a very stable nature. The only exception is in the vicinity of Cheyney. This would be expected because of Cheyney State College.

## EDUCATION

52. In 1974 public school enrollment was 62,561 in Chester County and 96,019 in Delaware County. As shown on Plate B-9, the Chester Creek Basin lies in portions of the following five school districts with total enrollments as listed:

| School District | Elementary | Secondary | Total |
|---|---|---|---|
| Chester-Upland | 6,531 | 5,227 | 11,758 |
| Garnet Valley | 857 | 1,032 | 1,889 |
| Penn-Delco | 2,758 | 2,888 | 5,646 |
| Rose Tree Media | 2,570 | 2,928 | 5,498 |
| West Chester Area | 6,395 | 5,672 | 12,067 |
| Total | 19,111 | 17,747 | 26,858 |

TABLE B-5
DURATION OF RESIDENCE
CHESTER CREEK BASIN 1/

| Year Moved Into Unit | DELAWARE COUNTY | BROOKHAVEN BOROUGH | CITY OF CHESTER | UPLAND BOROUGH | CHESTER COUNTY | WEST CHESTER BOROUGH |
|---|---|---|---|---|---|---|
| Total Owner Occupied | 131,690 | 1,861 | 18,718 | 747 | 55,002 | 2,250 |
| 1969-March 1970 | 6.0% | 4.4% | 0.9% | 6.6% | 8.8% | 7.8% |
| 1968 | 5.2 | 3.6 | 2.0 | 4.4 | 7.8 | 5.6 |
| 1965-1967 | 13.8 | 17.7 | 2.9 | 8.8 | 18.2 | 17.3 |
| 1960-1964 | 18.6 | 25.0 | 10.0 | 25.2 | 21.3 | 15.5 |
| 1950-1959 | 33.7 | 42.9 | 17.3 | 32.7 | 25.4 | 25.0 |
| 1949-Earlier | 22.7 | 6.4 | 66.9 | 22.3 | 18.4 | 28.8 |
| Total Renter Occupied | 48,979 | 126 | 9,144 | 359 | 23,399 | 2,575 |
| 1969-March 1970 | 33.1% | 59.5% | 0.0% | 24.8% | 37.0% | 33.6% |
| 1968 | 16.2 | 7.1 | 0.2 | 13.4 | 16.1 | 14.5 |
| 1965-1967 | 24.1 | 11.9 | 2.0 | 27.3 | 20.9 | 25.7 |
| 1960-1964 | 13.1 | 15.9 | 10.5 | 21.7 | 12.1 | 11.7 |
| 1950-1959 | 8.9 | 5.6 | 17.6 | 8.6 | 7.7 | 10.1 |
| 1949-Earlier | 4.6 | 0.0 | 69.7 | 4.2 | 6.2 | 4.4 |

1/ Source: Detailed Housing Characteristics for Pennsylvania based on 1970 census. Data presented are only for boroughs and cities with populations greater than 2500 persons. Delaware and Chester County data are included for comparison.

53. These figures do not include non-public schools in Chester and Delaware Counties which totaled 56,974 students in 1974 (36% of the public school enrollment). The current trend is for school enrollments to decline slightly in urban areas of the Basin while increasing slightly in less urban areas. This is caused by both migration of families from the urban areas and the recent decreases in the birth rate. In general, the schools in the Basin are operating at less than capacity.

54. Expenditures in the Basin's school districts are generally above the County averages as shown in the following table. The figures reported here are the expenditures per average daily attendance in 1974.

| School District | Expenditures Per Pupil |
|---|---|
| Chester-Upland | $1,721 |
| Garnet Valley | 1,716 |
| Penn-Delco | 1,188 |
| Rose Tree Media | 1,581 |
| West Chester Area | 1,421 |
| CHESTER COUNTY (AVERAGE) | 1,328 |
| DELAWARE COUNTY (AVERAGE) | 1,413 |

55. The average annual salaries for the teachers in the five districts range from $11,759 to $12,005. Average faculty experience ranges from 8.82 to 11.16 years with an average higher education level (above high school) of 4.57 to 5.08 years. The pupil to teacher ratio ranges from 17.2 to 21.8.

56. The level of student performance differs for each school district when compared with average county statistics. A comparison of grade 12 enrollment statistics is presented below for high schools in the five school districts and two counties. The statistics list percentages of the 1975 grade 12 population which graduated and enrolled in college or other advanced schooling.

| High Schools | Grade 12 Enrollment | Graduated (percent) | College (percent) | Other (percent) |
|---|---|---|---|---|
| Chester | 658 | 95 | 27 | 5 |
| Garnet Valley Sr. | 183 | 86 | 40 | 10 |
| Sun Valley | 473 | 93 | 33 | 7 |
| Penncrest | 496 | 98 | 63 | 3 |
| Henderson | 476 | 95 | 74 | 5 |
| CHESTER CO. TOTAL | 4,622 | 93 | 41 | 6 |
| DELAWARE CO. TOTAL | 8,007 | 95 | 47 | 5 |

# DEVELOPMENT AND ECONOMY

57. This subsection presents information on the development and uses of the resources of the Basin. Topics covered include the economic base, transportation facilities, and urbanization of the Basin. One of the first industries was a woolen mill which was started in 1810 in an old sawmill located in Concord Township. By 1875 the area's industries had grown to 314 factories and had a capital investment of approximately 6 million dollars and an annual production of 11.6 million dollars. At one time there were six shipyards located on the banks of the Delaware River. There were also about 90,000 acres of cultivated farmlands. Therefore, at a very early time, this area had an intensive manufacturing base with an extensive developed agricultural base. Lead and copper were mined at an early time although not extensively, and building stones were shipped to Philadelphia. In recent history, many of these industries have declined; especially, in the older more urban areas. However, future economic growth is projected for the area. The less developed middle portions of the Basin are expected to be the locations of future development and economic growth. Economic decline of the older, urbanized areas of the Basin is expected to be reversed. If this occurs, it will be the result of new service oriented industries.

## ECONOMIC BASE

58. The land area of the Basin is 11.2% of the two counties it lies in. The Basin has 8.6% of the two county population, but its industries amount to 23.1% of the total employment of the two counties. The Delaware County portion of Basin employment is 76%, a proportionate percentage since 67.6% of the Basin's land area lies in Delaware County. Chester County ranked 16th in the State in 1972 with 30,918 employees and Delaware County ranked 10th with 41,795. Of these, 4,065 and 12,728, respectively, were actually employed in the Chester Creek Basin; totalling 16,793 employees working for 166 establishments.

59. Out of the total Basin employed population (16 years old and over) of about 16,800, 78% are white and 22% black. Since the Basins' racial composition is about 76% white and 24% black, this indicates a higher rate of unemployment for black residents than for white residents. This reflects both regional and national trends. Table B-6 compares county and Basin employment figures. A slightly higher percentage of the workforce is employed in blue collar and service occupations while a significantly smaller percentage has agricultural occupations.

60. Basin economic activities result in about $708,545,000 in production

TABLE B-6
COUNTY AND BASIN
EMPLOYMENT STATISTICS 1/

| Occupation | Chester | Delaware | 2 Counties | Basin Totals | % of Basin Employed |
|---|---|---|---|---|---|
| TOTAL EMPLOYED | 108,718 | 238,624 | 347,342 | 38,097 2/ | 11.0% |
| WHITE COLLAR WORKERS-TOTAL | 56,401 | 140,034 | 196,435 | 19,638 | 10.0 |
| Professional, Technical & & Kindred workers | 35% | 32% | 33% | 39% | 11.2 |
| Managers & Administrators Except Farm | 18% | 15% | 16% | 15% | 9.8 |
| Sales Workers | 15% | 15% | 15% | 13% | 8.9 |
| Clerical & Kindred Workers | 32% | 38% | 36% | 33% | 9.4 |
| BLUE COLLAR OCCUPATIONS-TOTAL | 37,630 | 73,830 | 111,460 | 13,497 | 12.1 |
| Craftsmen, Foremen & Kindred Workers | 37% | 48% | 44% | 42% | 11.6 |
| Transport Equip. Operatives | 9% | 9% | 9% | 9% | 11.9 |
| Other Operatives | 41% | 34% | 36% | 37% | 12.4 |
| Laborers, Except Farm | 13% | 9% | 11% | 12% | 13.3 |
| AGRICULTURAL OCCUPATIONS-TOTAL | 3,769 | 862 | 4,631 | 207 | 4.5 |
| Farmers & Farm Mgr. | 47% | 35% | 45% | 23% | 2.3 |
| Farm Laborers & Foreman | 53% | 65% | 55% | 77% | 6.2 |
| SERVICE OCCUPATIONS-TOTAL | 10,918 | 23,898 | 24,816 | 4,755 | 13.7 |
| Service Workers, Except Private Households | 88% | 92% | 91% | 89% | 13.4 |
| Private Household Workers | 12% | 8% | 9% | 11% | 16.0 |

| Age of Labor Force | 2 County Total | Chester Creek Basin Only 3/ Total | White | Black | Other Races |
|---|---|---|---|---|---|
| BOTH SEXES-TOTAL POPULATION | 613,353 | 76,033 | 58,735 | 17,011 | 287 |
| BOTH SEXES-TOTAL IN LABOR FORCE | 359,041 | 44,043 | 34,107 | 9,760 | 176 |
| 16 to 19 Years Old | | 7.2% | 7.3% | 6.6% | 8.5% |
| 20 to 24 Years Old | | 11.4 | 10.4 | 15.0 | 9.6 |
| 25 to 44 Years Old | | 42.4 | 41.9 | 43.6 | 54.5 |
| 45 to 64 Years Old | | 35.7 | 37.5 | 29.9 | 24.4 |
| MEDIAN AGE OF LABOR FORCE-BOTH SEXES | | 41.1 | 41.7 | 38.7 | 39.3 |
| MALE-TOTAL POPULATION | 289,830 | 36,273 | 28,651 | 7,529 | 93 |
| MALE-TOTAL IN LABOR FORCE | 229,243 | 27,962 | 22,375 | 5,503 | 84 |
| 16 to 19 Years Old | | 6.6% | 6.4% | 7.4% | 9.6% |
| 20 to 24 Years Old | | 10.0 | 8.9 | 14.4 | 11.9 |
| 25 to 49 Years Old | | 44.0 | 44.6 | 41.9 | 48.8 |
| 45 to 64 Years Old | | 36.0 | 37.3 | 30.8 | 23.8 |
| MEDIAN AGE OF LABOR FORCE-MALE | | 41.3 | 41.8 | 39.3 | 36.5 |
| FEMALE-TOTAL POPULATION | 323,523 | 39,760 | 39,084 | 9,482 | 194 |
| FEMALE-TOTAL IN LABOR | 129,798 | 16,081 | 11,732 | 4,257 | 92 |
| 16 to 19 Years Old | | 8.1% | 9.0% | 5.5% | 7.6% |
| 20 to 24 Years Old | | 13.8 | 13.2 | 15.8 | 7.7 |
| 25 to 49 Years Old | | 39.4 | 36.9 | 45.8 | 59.7 |
| 45 to 64 Years Old | | 35.2 | 37.7 | 28.8 | 25.0 |
| MEDIAN AGE OF LABOR FORCE-FEMALE | | 40.6 | 41.6 | 38.0 | 40.5 |

1/ Source: Summary of Manpower Indicators for Chester Creek Basin as compiled by the U.S. Department of Labor, 1970 Census of Population.
2/ Figure does not include 4,671 workers whose occupation was not reported.
3/ Include entire political subdividion even if only a portion lies within the Basin.

and $399,025,000 in value added. The top six industrial groups provide 78% of the value of production within the Basin and 80% of the value added by manufacturing within the Basin. Comparing employment and production percentages for the top six industries we have:

| Type of Industry | No. of Establishments | Value of Production | Value Added | % of Basin Employment |
|---|---|---|---|---|
| Paper & Allied Prod. | 8 | 19.9% | 21.0% | 15.8% |
| Transportation Equip. | 2 | 15.7 | 19.7 | 23.4 |
| Chemical & Allied Prod. | 8 | 14.6 | 18.5 | 7.6 |
| Misc. Manufacturing | 2 | 11.9 | 9.1 | 8.3 |
| Fabricated Metals | 28 | 8.1 | 6.7 | 10.4 |
| Food & Kindred Prod. | 12 | 7.5 | 5.2 | 7.0 |

61. Of these, the two most labor intensive industries, transportation and fabricated metals amounted to 33% of the employment within the Basin and 26% of value added by manufacturing. The two most capital intensive industries, paper and chemicals, amounted to 23% of the employment and 40% of the value added by manufacturing. In 1969, Chester County was number 1 in the nation for value of nursery and greenhouse products sold. Chester County is also known as the Mushroom Capital of the World because it is the nation's leading producer of mushrooms. In 1969 Delaware County ranked 4th in the State in Manufacturing. Durable goods manufacturers employ two-thirds of the manufacturing work force in the county, but because of several large capital intensive industries (paper, chemical, and petroleum), durable goods have less than 50% of the value of production.

62. Mean family income for the Basin was $11,330 in 1970 compared with $10,999 for the entire United States. There is considerable variation in mean family income both between the counties and the major urban areas, as noted in the following tabulation.

| | Mean Income (1970 Dollars) | Number of Families in Basin |
|---|---|---|
| Delaware County | $11,779 | 20,670 |
| Chester City | 8,491 | 7,246 |
| Upland Borough | 10,453 | 964 |
| Chester County | $14,217 | 6,041 |
| West Chester Borough | 9,121 | 979 |

63. Median family income in the area was $11,233 per year. Some 27% of the families in the Basin received more than $15,000. About 15% were "near poor" having incomes less than 125 percent of the poverty level, and 8% were "poor poor" with incomes less than 75% of the poverty level. Income statistics are presented on Table B-7. This table lists median incomes by profession and selected poverty level data.

TABLE B-7
EARNINGS STATISTICS
CHESTER CREEK BASIN 1/

| | Total | White | Black | Other Races |
|---|---|---|---|---|
| **Male Earnings** | | | | |
| Professional, Managerial & Kindred Workers | $12,437 | $12,600 | $8,124 | $13,025 |
| Craftsman, Foremen & Kindred Workers | 8,930 | 9,239 | 6,584 | 5,500 |
| Operatives, Including Transport | 7,393 | 7,947 | 6,535 | 4,500 |
| Laborers, Except Farm | 5,203 | 5,269 | 5,098 | 3,500 |
| Farmers & Farm Managers | 5,928 | 5,928 | 6,000 | 6,500 |
| Farm Laborers Except Unpaid & Farm Foremen | 2,389 | 3,479 | 676 | 6,500 |
| Total Male Experienced Labor Force | 8,457 | 9,231 | 4,815 | 1,478 |
| **Female Earnings** | | | | |
| Clerical & Kindred Workers | 4,209 | 4,275 | 3,810 | 2,667 |
| Operatives Including Transport | 3,775 | 3,953 | 3,461 | 4,250 |
| Total Female Experienced Labor Force | 3,690 | 3,915 | 3,190 | 4,111 |
| **Poverty Level Indicators** | | | | |
| Families Below Poverty Level | 2,559 | 821 | 1,721 | 17 |
| Total Number of Persons in Families Below Poverty Level | 9,475 | 2,672 | 6,772 | 31 |
| Percentage of Male Heads of Poverty Families | 45.5 | 55.3 | 40.7 | 0.0 |
| Percentage of Female Heads of Poverty Families | 54.5 | 44.7 | 59.2 | 100.0 |

1/ All data was extracted from the Summary of Manpower Indicators for Chester Creek Basin as compiled by the U.S. Department of Labor, 1970 Census of Population.

## ECONOMIC TRENDS

64. Chester County has benefitted greatly from the migration of industry and population to the suburbs. Its industrial mix is relatively good, with biggest employers being primary metals and food and kindred products. A review of Plate B-10 shows employment dropped from 1969 to 1972 but made an upturn from 1972-73. Wages and salaries, and value of production level dropped between 1969 and 1971 but both continued to show strong upward trends. Chester County is rated 4th in the State in level of economic development and second according to economic growth.

65. Delaware County, on the otherhand, has suffered a slight net out-migration of 1.6% of the population change (almost 9000 persons). An industrial mix is lacking. Its two largest employers are machinery (except electrial) and transportation equipment. They usually react similarly in economic upturns or downturns. Plate B-10 shows the same adverse economic turns betwen 1968 and 1972 as Chester County, but to a much more exaggerated degree. Employment doesn't show the same upturn in 1972. Wages and salaries and value of production do not show the same overall strength as was indicated in Chester County. Delaware County was rated 2nd in the State in level of economic development but only 29th according to economic growth.

## TRANSPORTATION FACILITIES

66. The Chester Creek Basin is in an area with excellent transportation facilities due to its location along the populous New York-Philadelphia-Washington corridor. There are major rail lines and interstate highways serving the area. The Basin is adjacent to the Delaware River which provides waterborne transportation and is near the Philadelphia International Airport.

67. Plate B-11 shows the State and Federal highway network in the Basin. A brief description of these facilities is as follows:

East-West Routes

PA 291 - 2 Lanes - Major free access local route for both automobiles and trucks.
US 13 - 2 Lanes (4 in some areas) - Major free access local route for both automobile and trucks.
I-95 - 4 Lanes (6 in some areas) - Major regional limited access route connecting Basin with Philadelphia, Pennsylvania and Wilmington, Delaware.

US 1 - 4 Lanes - Major free access facility for both automobiles and trucks.
PA 3 - 4 Lanes - Major regional free access facility connecting West Chester with Philadelphia.

North-South Routes

PA 352 - 2 Lanes - Free access local facility connecting Chester with the Media area.
PA 452 - 2 Lanes - Free access local facility connecting Marcus Hook and the suburbs to the north.
PA 261 - 2 Lanes (4 Lanes south of the Basin).
US 322 - 4 Lanes - Major regional free access facility connecting West Chester and Chester. This is a major truck route in the area and is the major approach route to the new Commadore Barry Bridge spanning the Delaware River. An access bypass skirts West Chester.
US 202 - 4 Lane - Major free access facility for both automobiles and trucks. Follow same route as US 322 around West Chester.

68. Pennsylvania Department of Transportation (PENNDOT) has plans to upgrade PA 291 using the existing alignment through the Basin.

69. Because of its highly industrialized nature, the City of Chester is served by several rail lines: ConRail (formerly Reading and Penn Central) and Chessie (formerly Baltimore and Ohio). Both have freight lines through the City which parallel the Delaware. ConRail also provides frieght service from Philadelphia to West Chester and north. The Southeastern Pennsylvania Transportation Authority (SEPTA) has purchased the Octoraro Branch of the Penn Central Railroad running from Lenni to Colora, Maryland. Much of the line is currently in disrepair. Freight service from the West to Lenni was initiated during the summer of 1977. Additional freight service and passanger service are planned for the future.

70. Commuter service to Philadelphia is provided by two commuter lines. Passenger service from Chester to Philadelphia (and points north) and Wilmington, Delaware (and points south) is provided with connections to Amtrak at Philadelphia and Wilmington. The second line begins in West Chester and passes through Cheyney, Wawa, and Media enroute to Philadelphia. Both lines concentrate their service in the morning and evening rush hours with limited service during other times.

71. There are no rapid transit facilities in the Basin. However, SEPTA operates a light rail facility between Media and Philadelphia. SEPTA's Red Arrow Division operates a network of bus routes in Delaware and Chester Counties connecting other Counties and Philadelphia.

72. Table B-8 gives a description of the commutation patterns for the

TABLE B-8
COMMUTER PATTERNS
CHESTER AND DELAWARE COUNTIES

JOURNEY TO WORK PATTERNS - TO AND FROM CHESTER COUNTY (CHESCO)

| Location | 1970 Work in CHESCO and Come From | 1970 Live in CHESCO and Work in | 1960 Live in CHESCO and Work in |
|---|---|---|---|
| TOTAL | 85,989 | 106,902 | 76,906 |
| Delaware Co. | 6.27% | 6.06% | 3.72% |
| Chester Co. | 77.16 | 62.06 | 74.42 |
| Philadelphia | 3.24 | 7.02 | 6.57 |
| Other Pa. Counties | 10.74 | 13.82 | 8.20 |
| Out of State | 2.59 | 11.04 | 7.07 |

JOURNEY TO WORK PATTERNS-TO AND FROM DELAWARE COUNTY (DELCO)

| Location | 1970 Work in DELCO and Come From | 1970 Live in DELCO and Work in | 1960 Live in DELCO and Work in |
|---|---|---|---|
| TOTAL | 159,220 | 231,242 | 202,869 |
| Delaware Co. | 77.76% | 52.15% | 53.11% |
| Chester Co. | 4.07 | 2.33 | 1.51 |
| Philadelphia | 10.38 | 30.79 | 35.70 |
| Other Pa. Counties | 4.23 | 6.77 | 4.78 |
| Out of State | 5.55 | 7.93 | 4.90 |

two counties. As would be expected by their respective locations, a much larger percentage of Delaware County's work force is employed in Philadelphia than is the case in Chester County. However, while the percentage of Chester County workers employed in Philadelphia has increased, Delaware County's has decreased. Between 80 and 90% of the commuters in the Basin drive their own vehicles or are passengers in a private vehicle. This figure drops to 66% in the City of Chester. About 50 percent of the workers living in the City of Chester work there. About 13 percent of these people walk to work.

## URBANIZATION

73. The term "urbanization" refers to a condition in which a natural terrain is developed for residential, commercial, and industrial purposes. Urbanization directly effects climatic and hydrologic conditions; factors such as cultural, recreational and business activities of the population; land cover and wildlife; and the amount of required services, such as water supply and wastewater. Urbanization can effect such climatic variables as temperature, sunlight, humidity, wind speed and precipitation. In addition, urbanization changes the path of a drop of water in its never ending cycle. Urbanization enables quicker collection and transportation of water to large receiving waters. It stops water from reaching aquifers. The influx of people and its accompanying services and activities requires increased water use and the disposal of wastewater. Higher land values in urban areas make land within the flood plain more attractive. At the same time, urbanization limits land for recreational use while there is an increase in the need for recreation.

74. The Delaware Valley Region is experiencing urbanization at an increasing rate as shown in Plate B-12. Future expansion is expected to continue to basically radiate from the center of the city. The character of this development is similar to that of most urbanizing areas and includes many major new residential communities, commercial shopping centers and malls, and industrial parks.

75. Communities in the Chester Creek Basin have experienced a great degree of urbanization in the recent past. Urbanization is expected to increase in the future. The density of population in the Basin has increased considerably in the past and is predicted to continue in the future. Even the City of Chester, which has lost population in recent years, is expected to regain it in the more distant future. A comparison of the Basin's population density with other selected densities is presented below.

| | | |
|---|---|---|
| Chester Creek Basin | 1,116 | (persons per sq. mile) |
| Chester County | 365 | |
| Delaware County | 3,253 | |
| Philadelphia SMSA | 1,775 | |
| Pennsylvania | 262 | |

76. An analysis of future urbanization and its effects on flooding was conducted as part of this study. This analysis is described in Section G.

## DESCRIPTIVE PUBLICATIONS

77. This sub-section identifies and briefly describes noteworthy maps and publications describing the study area, other than the normal sources of statistical information and prior and current studies and reports.

Manpower Indicators for Chester Creek Basin, U.S. Department of Labor, Manpower Administration Data Systems and Reports, Region III;data on the 1970 basin population, employment and income, broken down by race, sex and age.

Quarterly Reports, Water Quality Samples, Commonwealth of Pennsylvania, Department of Environmental Resources; a series of quarterly reports dating back to 1962 which present data from water quality sampling throughout the Commonwealth, including the Chester Creek Basin.

Water Resources Bulletin, Bulletin No. 1, Commonwealth of Pennsylvania, Department of Forests and Waters, April 1966; presents data on low flow frequencies and durations for all streams in the Commonwealth, including Chester Creek.

Water Resources Bulletin, Bulletin No. 6, Commonwealth of Pennsylvania Department of Forests and Waters, December 1970; presents maps and tabular data on all streams and rivers in the Commonwealth, including those in the Chester Creek Basin.

Water Resources Bulletin, Bulletin No. 7, Commonwealth of Pennsylvania Department of Environmental Resources, Office of Engineering and Construction, December 1972; presents data on long duration low flows for streams in the Commonwealth, including Chester Creek.

Atlas of Chester County, Pennsylvania, published by the Chester County Planning Commission, July 1971; a collection of maps showing physical, economic and social data for Chester County.

Chester County Geology, published by the Chester County Planning Commission, June 1973; presents geologic information for Chester County.

Community Facilities Inventory of Human Services and Facilities in Chester County, Chester County Planning Commission, March 1973; inventories health organizations, hospitals, health services, visiting nurse associations, facilities for the elderly, children's services and programs, alcohol and drug abuse services and educationsl facilities.

Open Space Inventory, Chester County Planning Commission, March 1973; inventories various types of open space in Chester County.

Housing Analysis, Chester County Planning Commission, February 1973; a detailed analysis of housing throughout the County with special emphasis given to housing for low and moderate income and minority groups.

Chester County Pennsylvania Interim Plan, Chester County Planning Commission; 1974; presents the County's comprehensive plan and detailed mapping which was developed in background studies.

Water Resources Planning Population Projections, 1975-1990, Chester County Water Resources Authority, January 1973, presents both high and low ranges of population for each municipality in the County.

Housing: Choices and Constraints, Report 2, Delaware County Planning Commission, August 1973; report focusing on housing availability and impediments to residential construction in Delaware County.

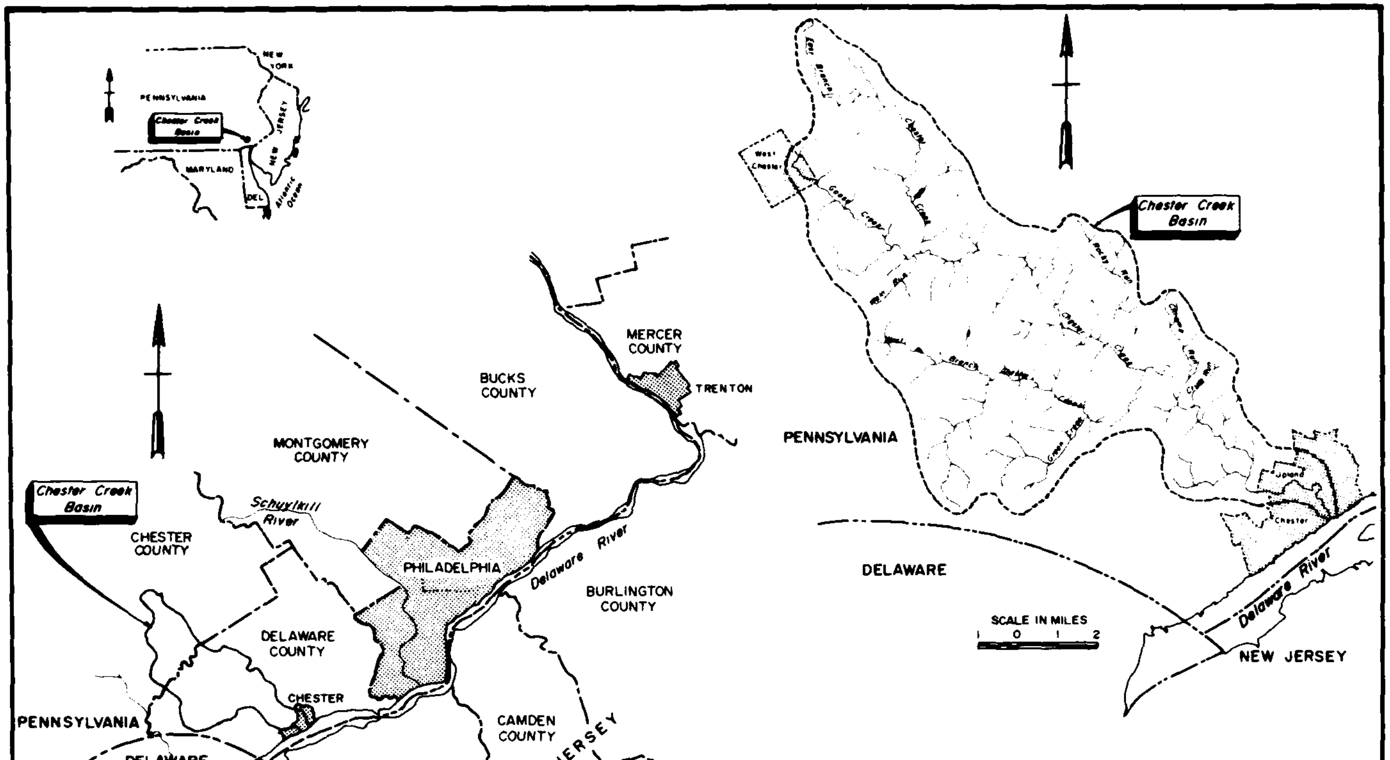
Delaware County, Open Space, Parks and Recreation Study, Draft Report, prepared by Von Storch and Burkavage, Direction Associates, Inc. for the Delaware County Commissioners, July 1975; includes an inventory of existing park and recreation areas, data on projected needs, and recommendations for meeting these needs.

Comprehensive Plan for the City of Chester, prepared by the Division of City Planning, City of Chester, October 1972; presents the City of Chester's comprehensive plan and detailed mapping which was developed during development of the plan.

Flora of Chester County, Hugh E. Stone, the Academy of Natural Sciences, Philadelphia, Pennsylvania, 1945; gives very complete information on the plant life found in Chester County.

Water Resources Bulletin, Bulletin No. 5, Commonwealth of Pennsylvania Department of Forests and Waters, 1970; presents data on all dams, reservoirs, and natural lakes in the Commonwealth, including dam classification, type and use.

Water Resources Bulletin, Bulletin No. 12, Commonwealth of Pennsylvania Department of Environmental Resources; presents data on the low flow characteristics of all streams in the Commonwealth, including Chester Creek.

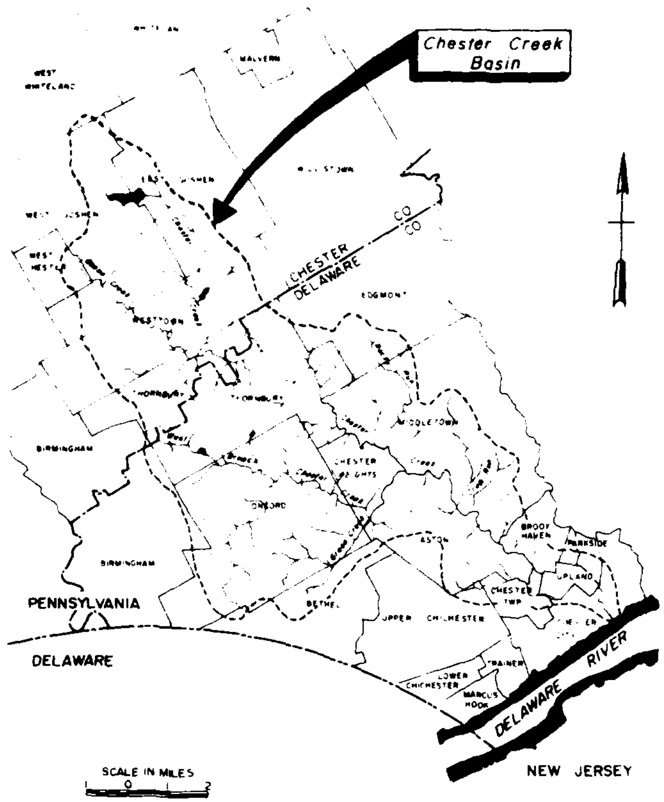



CHESTER CREEK BASIN, PENNSYLVANIA

STUDY AREA LOCATION

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE B-1




POLITICAL SUBDIVISION

DELAWARE COUNTY

ASTON TOWNSHIP
BETHEL TOWNSHIP
BIRMINGHAM TOWNSHIP
BROOKHAVEN BOROUGH
CITY OF CHESTER
CHESTER HEIGHTS BOROUGH
CHESTER TOWNSHIP
CONCORD TOWNSHIP
EDGMONT TOWNSHIP
MIDDLETOWN TOWNSHIP
PARKSIDE BOROUGH
THORNBURY TOWNSHIP
UPLAND BOROUGH
UPPER CHICHESTER TOWNSHIP

CHESTER COUNTY

BIRMINGHAM TOWNSHIP
EAST GOSHEN TOWNSHIP
THORNBURY TOWNSHIP
WEST GOSHEN TOWNSHIP
WEST CHESTER BOROUGH
WESTTOWN TOWNSHIP
WEST WHITELAND TOWNSHIP

CHESTER CREEK BASIN, PENNSYLVANIA

POLITICAL SUBDIVISIONS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

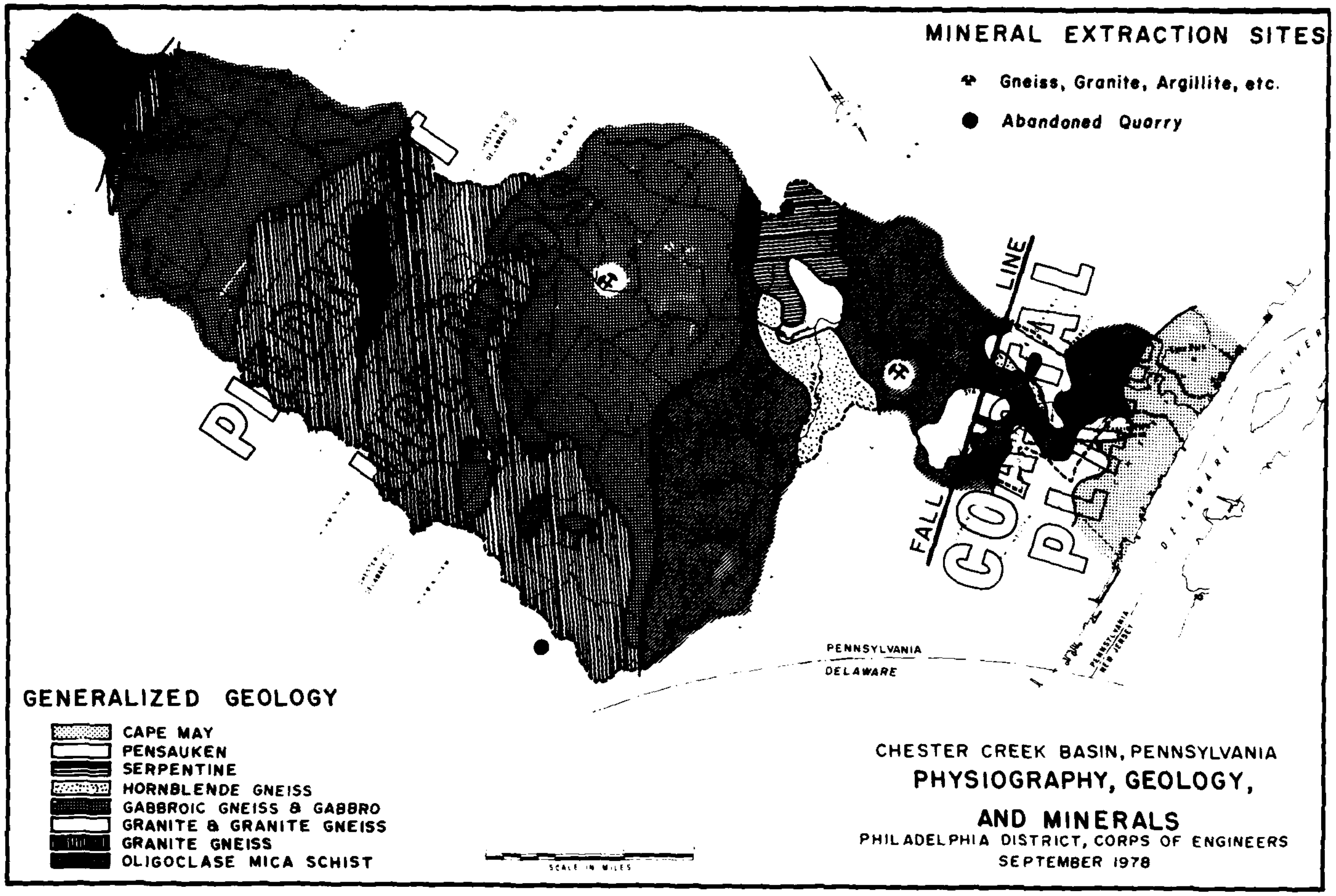
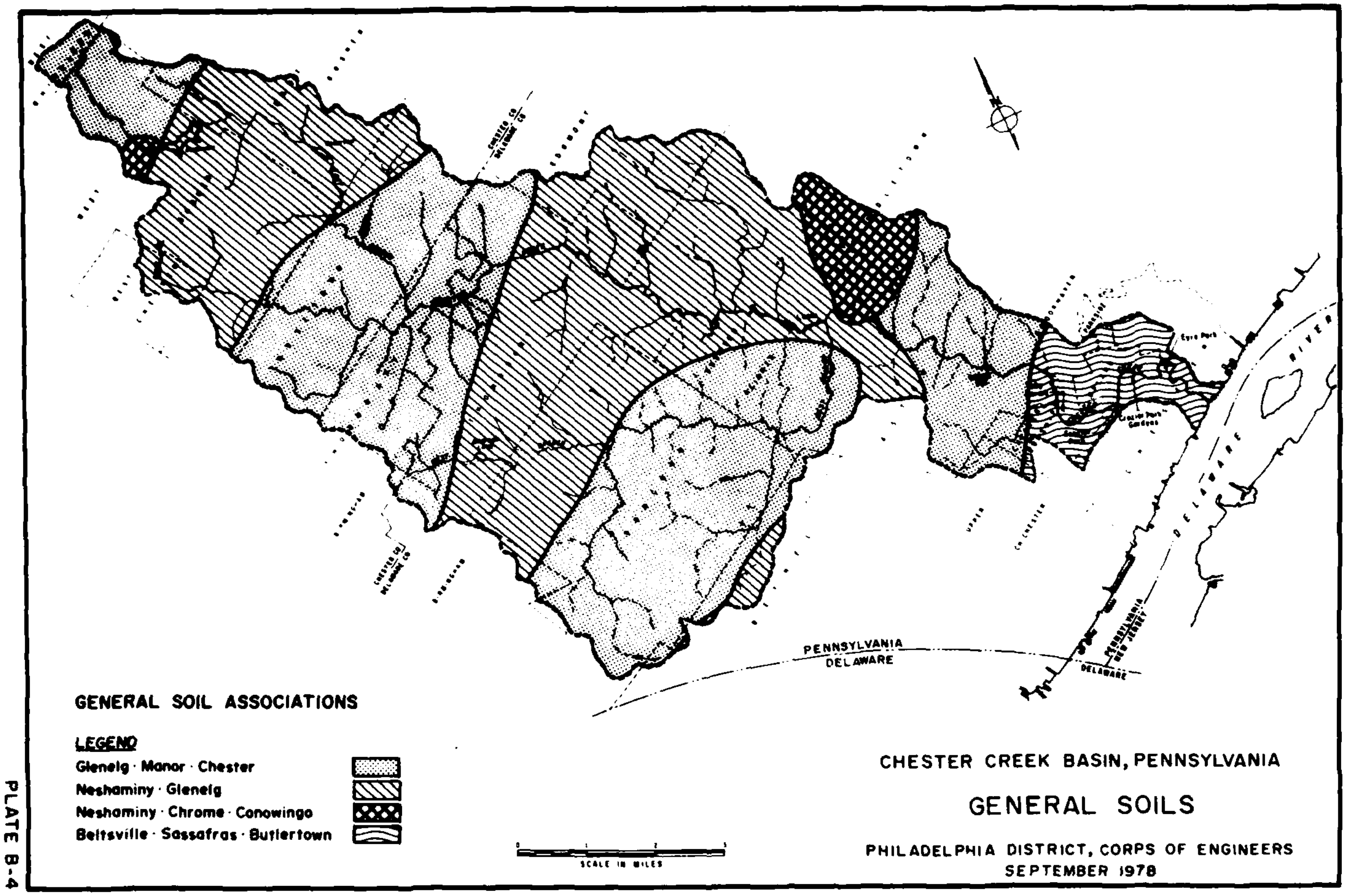
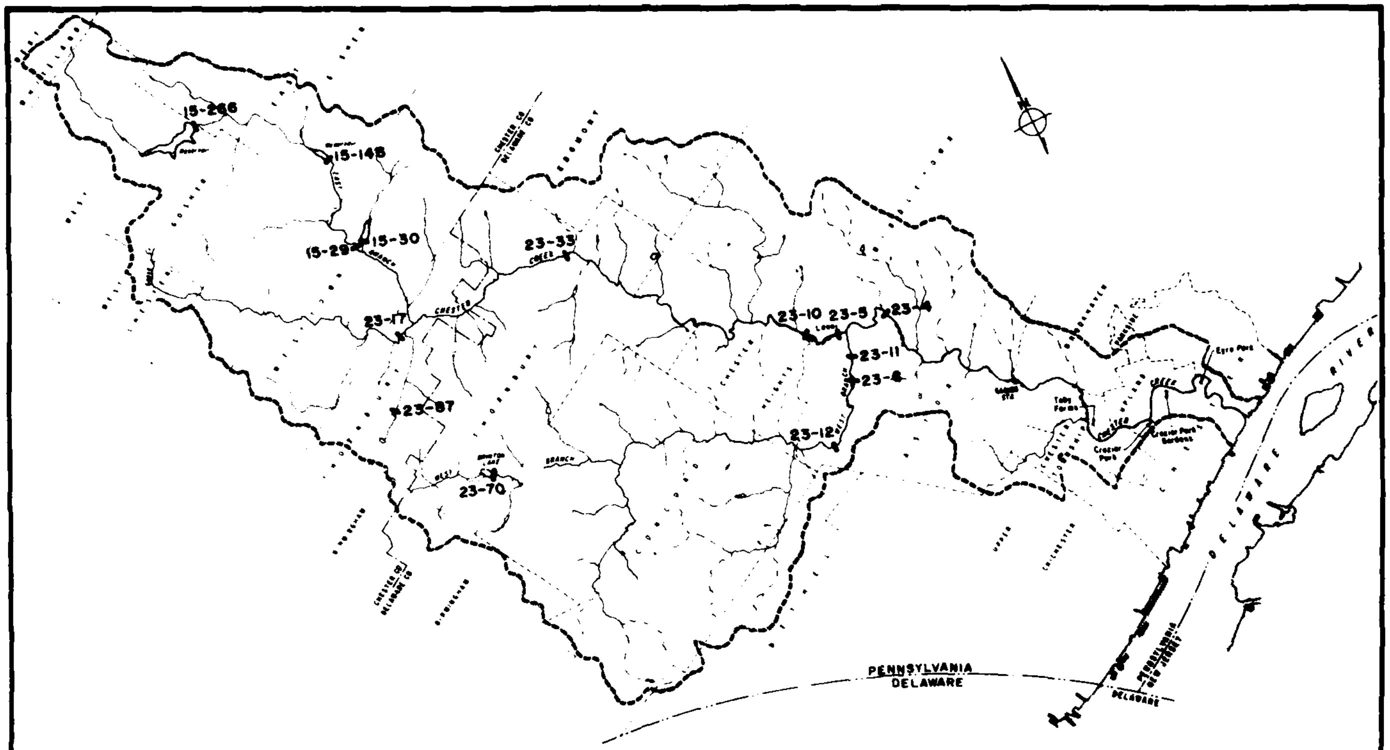

MINERAL EXTRACTION SITES
Gneiss, Granite, Argillite, etc.
Abandoned Quarry
FALL LINE
COASTAL PLAIN
PIEDMONT
PENNSYLVANIA
DELAWARE
PENNSYLVANIA
NEW JERSEY
DELAWARE RIVER
GENERALIZED GEOLOGY
CAPE MAY
PENSAUKEN
SERPENTINE
HORNBLENDE GNEISS
GABBROIC GNEISS & GABBRO
GRANITE & GRANITE GNEISS
GRANITE GNEISS
OLIGOCLASE MICA SCHIST
SCALE IN MILES
CHESTER CREEK BASIN, PENNSYLVANIA
PHYSIOGRAPHY, GEOLOGY,
AND MINERALS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE B-3



GENERAL SOIL ASSOCIATIONS
LEGEND
Glenelg · Manor · Chester
Neshaminy · Glenelg
Neshaminy · Chrome · Conowingo
Beltsville · Sassafras · Butlertown
SCALE IN MILES
PENNSYLVANIA
DELAWARE
DELAWARE RIVER
CHESTER CREEK BASIN, PENNSYLVANIA
GENERAL SOILS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978


PLATE B-4




NOTE:
Only dams with permits issued by the Commonwealth of Pennsylvania are located on this map. Permit numbers are shown.

CHESTER CREEK BASIN, PENNSYLVANIA

DAMS AND RESERVOIRS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE B-5

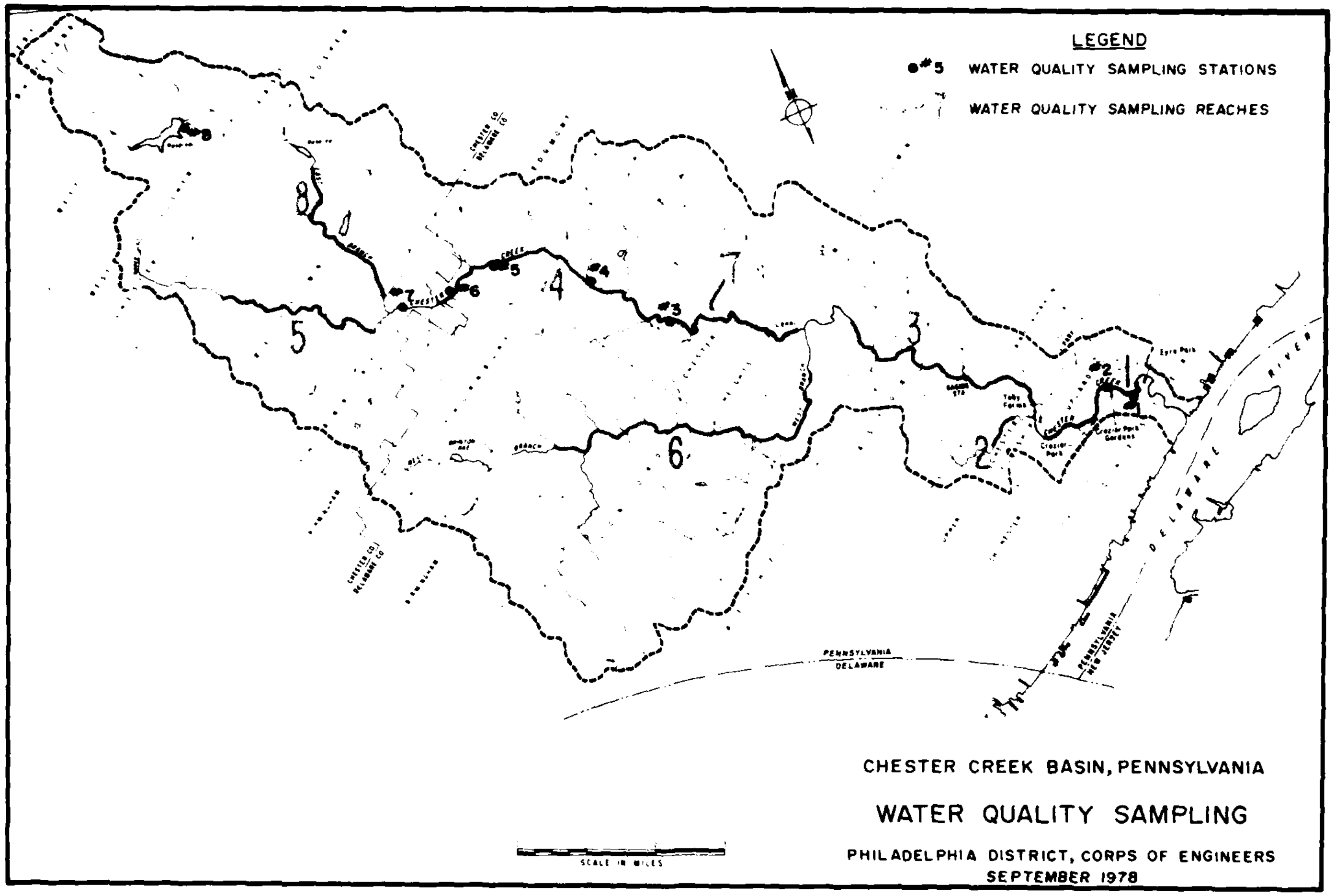
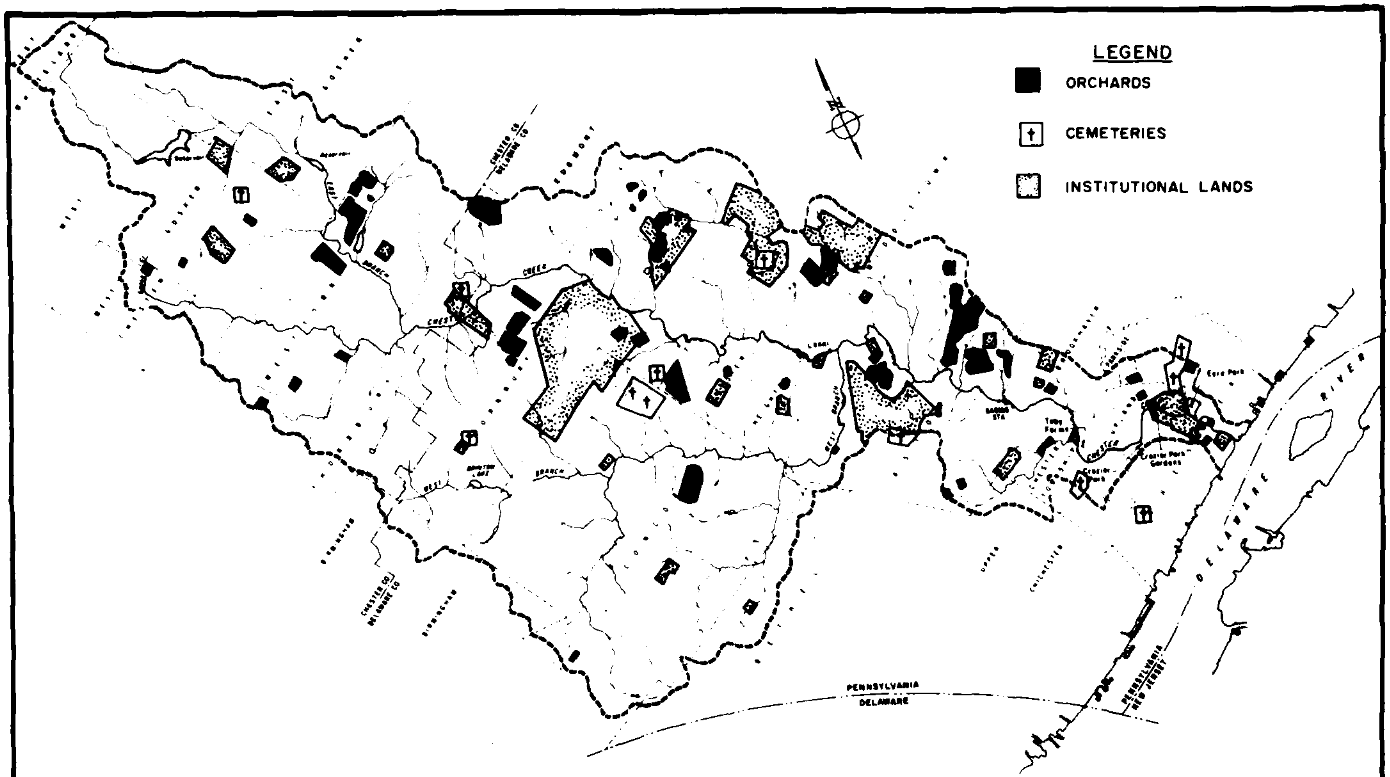
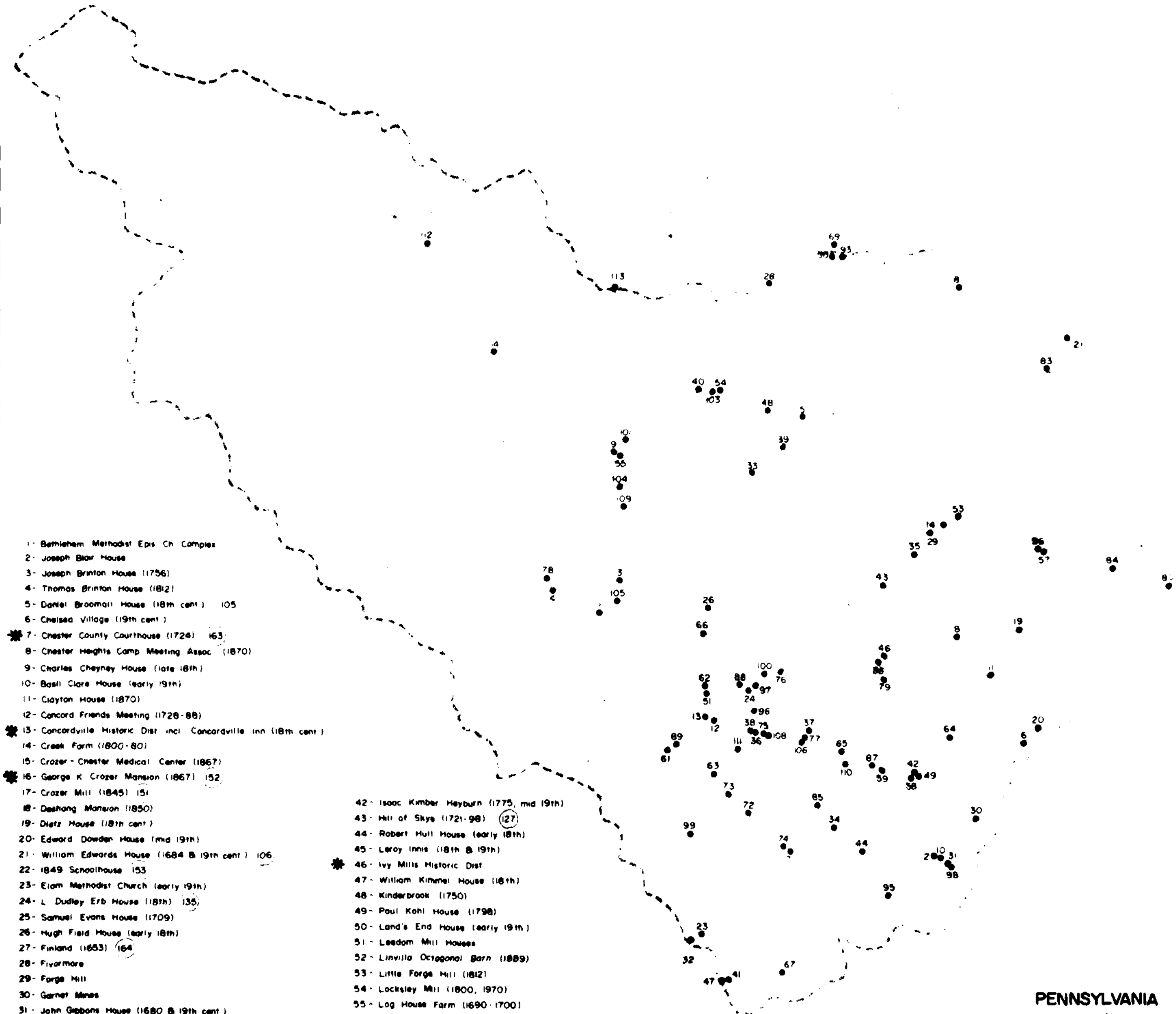

LEGEND
#5 WATER QUALITY SAMPLING STATIONS
WATER QUALITY SAMPLING REACHES
CHESTER CO.
DELAWARE CO.
DELAWARE RIVER
PENNSYLVANIA
DELAWARE
PENNSYLVANIA
NEW JERSEY
SCALE IN MILES
CHESTER CREEK BASIN, PENNSYLVANIA
WATER QUALITY SAMPLING
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE B-6




CHESTER CREEK BASIN, PENNSYLVANIA
ORCHARDS, CEMETERIES AND INSTITUTIONAL LANDS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

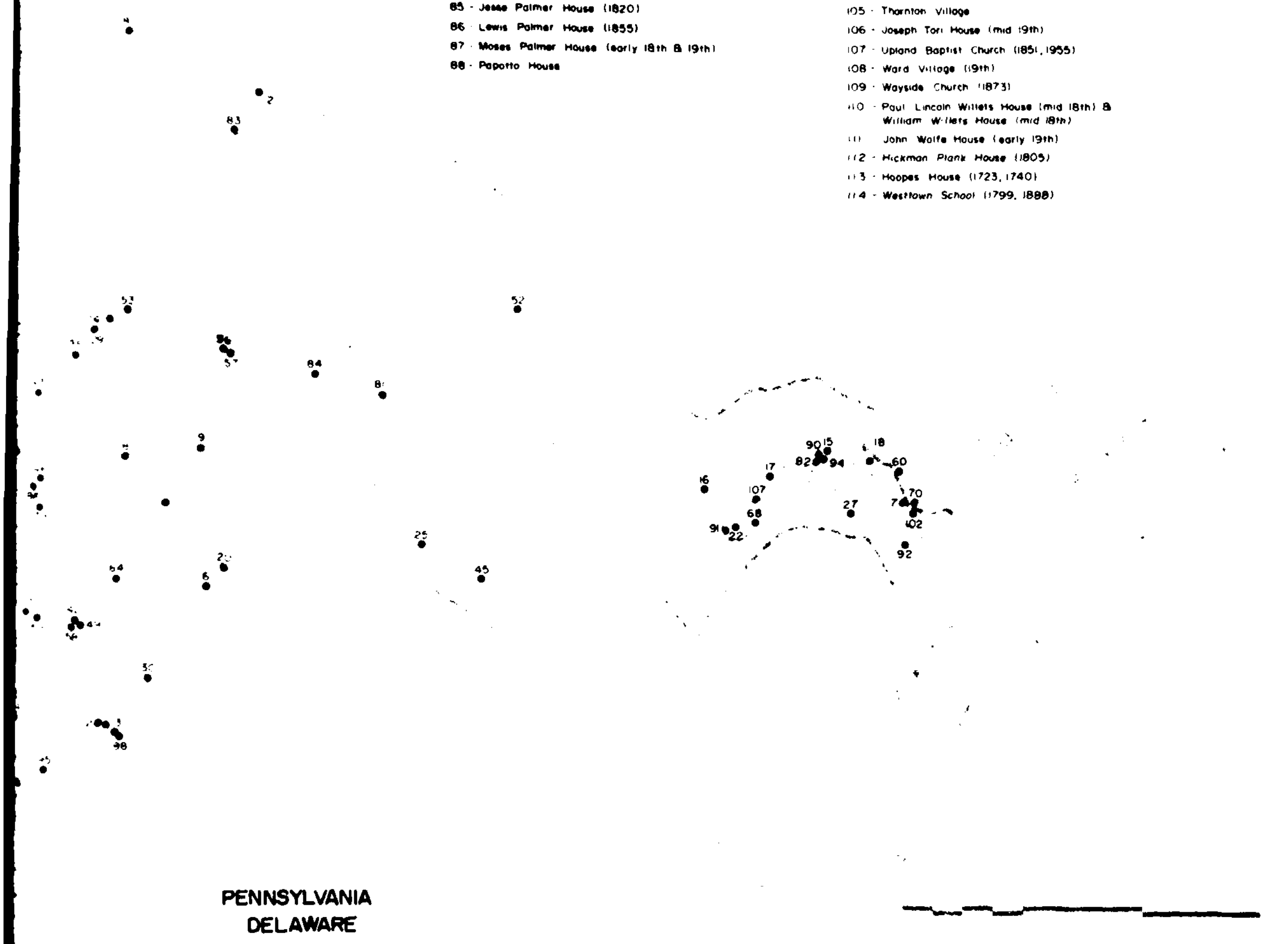
PLATE B-7




1 - Bethlehem Methodist Epis Ch Complex
2 - Joseph Blair House
3 - Joseph Brinton House (1756)
4 - Thomas Brinton House (1812)
5 - Daniel Broomall House (18th cent ) 105
6 - Chelsea Village (19th cent )
* 7 - Chester County Courthouse (1724) 163
8 - Chester Heights Camp Meeting Assoc (1870)
9 - Charles Cheyney House (late 18th)
10 - Basil Clare House (early 19th)
11 - Clayton House (1870)
12 - Concord Friends Meeting (1728-88)
* 13 - Concordville Historic Dist incl Concordville Inn (18th cent )
14 - Creek Farm (1800-80)
15 - Crozer - Chester Medical Center (1867)
* 16 - George K Crozer Mansion (1867) 152
17 - Crozer Mill (1845) 151
18 - Deshong Mansion (1850)
19 - Dietz House (18th cent )
20 - Edward Dowden House (mid 19th)
21 - William Edwards House (1684 & 19th cent ) 106
22 - 1849 Schoolhouse 153
23 - Elam Methodist Church (early 19th)
24 - L Dudley Erb House (18th) 135
25 - Samuel Evans House (1709)
26 - Hugh Field House (early 18th)
27 - Finland (1653) 164
28 - Fivormore
29 - Forge Hill
30 - Garnet Mines
31 - John Gibbons House (1680 & 19th cent )
32 - Eskil Gidholm (mid 19th)
33 - Glen Mills School (1882-92)
34 - William Greener House (18th)
35 - Hamanassett (1856)
36 - Handwrought (1805)
37 - John Hannum House (1700-1840)
38 - Peter Hatton House (early 18th)
39 - Hemphill House (1798 & 19th cent )
40 - Ann Henderson House (1846) 103
41 - Hewlin House (1805)
42 - Isaac Kimber Hayburn (1775, mid 19th)
43 - Hill of Skye (1721-98) 127
44 - Robert Hull House (early 18th)
45 - Leroy Innis (18th & 19th)
* 46 - Ivy Mills Historic Dist
47 - William Kimmel House (18th)
48 - Kinderbrook (1750)
49 - Paul Kohl House (1798)
50 - Land's End House (early 19th )
51 - Leedom Mill Houses
52 - Linvilla Octagonal Barn (1889)
53 - Little Forge Mill (1812)
54 - Locksley Mill (1800, 1970)
55 - Log House Farm (1690-1700)
56 - Lundgren House (19th)
57 - Lundgren Mills Houses (19th)
58 - Charles MacAteer House (18th)
59 - John MacCloskey House (mid 19th)
60 - Madison St Methodist Church (1874)
61 - David Manley House (1873)
62 - James Marshall Cottage (1775)
63 - Thomas Marshall House (1760-late 19th)
64 - Levi Mattson House (1803)
65 - Dorothy McQuillan House (mid 18th)
66 - Mendenhall Farm (1713-1830)
67 - Richard Mendenhall House (18th)
68 - Mill Houses (1845-47)

NOTE: * Denotes that site is on the National Register of Historic Places

69 - Miller House (mid 19th)
70 - John Morton Grave (1777)
71 - Joseph Murter House (1875)
72 - Jesse Myers House (19th)
73 - John Myers House (1801)
74 - Samuel Myers Farm (19th)
* 75 - Nicholas Newlin House (1742)
76 - Newlin Mill Complex (1739, 1742)
77 - Nicklin - Trimble House (1720, 1822)
78 - 1901 Schoolhouse
79 - Harry Norton House (early 18th)
80 - Old Dutton House (late 18th)
81 - Old Forge (1750, 1838)
* 82 - Old Main (1858)
83 - Old Middletown Friends Meeting (1770)
84 - Our Lady of Angels Convent and College (1879)
85 - Jesse Palmer House (1820)
86 - Lewis Palmer House (1855)
87 - Moses Palmer House (early 18th & 19th)
88 - Papotto House
89 - Parnell's Garden Center
90 - Pear Hall (1871)
* 91 - Pennock Log House (1790) & Caleb Pusey House (1683, 1696)
* 92 - William Penn's Landing Site
93 - William J Poinsett House (late 18th)
94 - Pollard House (1868) & Presidents House (1868) & Sunnyside (1863)
95 - George Poole House (1850)
96 - Alexander Scott House (1840),
97 - Scott Tenant House (1817)
98 - Shaffer Log House (1680)
99 - George Sharpless (1800)
* 100 - Sharpless House (1725)
101 - Smith - Swarthmore House (1786)
102 - Swedish Burial Ground
103 - Tenant House (1760)
104 Thornbury Hall (1860)
105 - Thornton Village
106 - Joseph Tori House (mid 19th)
107 - Upland Baptist Church (1851, 1955)
108 - Ward Village (19th)
109 - Wayside Church (1873)
110 - Paul Lincoln Willets House (mid 18th) & William Willets House (mid 18th)
111 John Wolfe House (early 19th)
112 - Hickman Plank House (1805)
113 - Hoopes House (1723, 1740)
114 - Westtown School (1799, 1888)



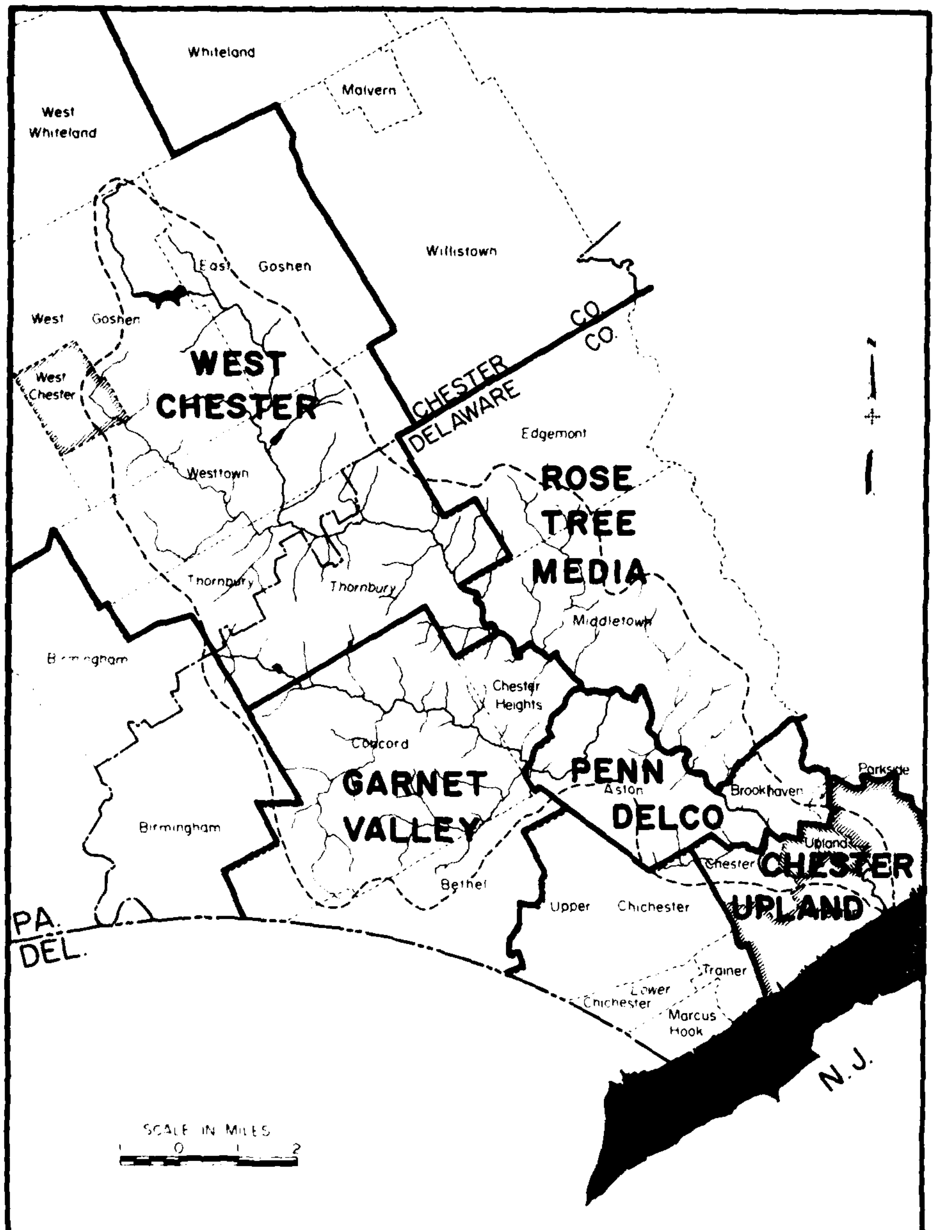

hat site is on the
Register of Historic Places

CHESTER CREEK BASIN, PENNSYLVANIA

HISTORIC SITES

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

2

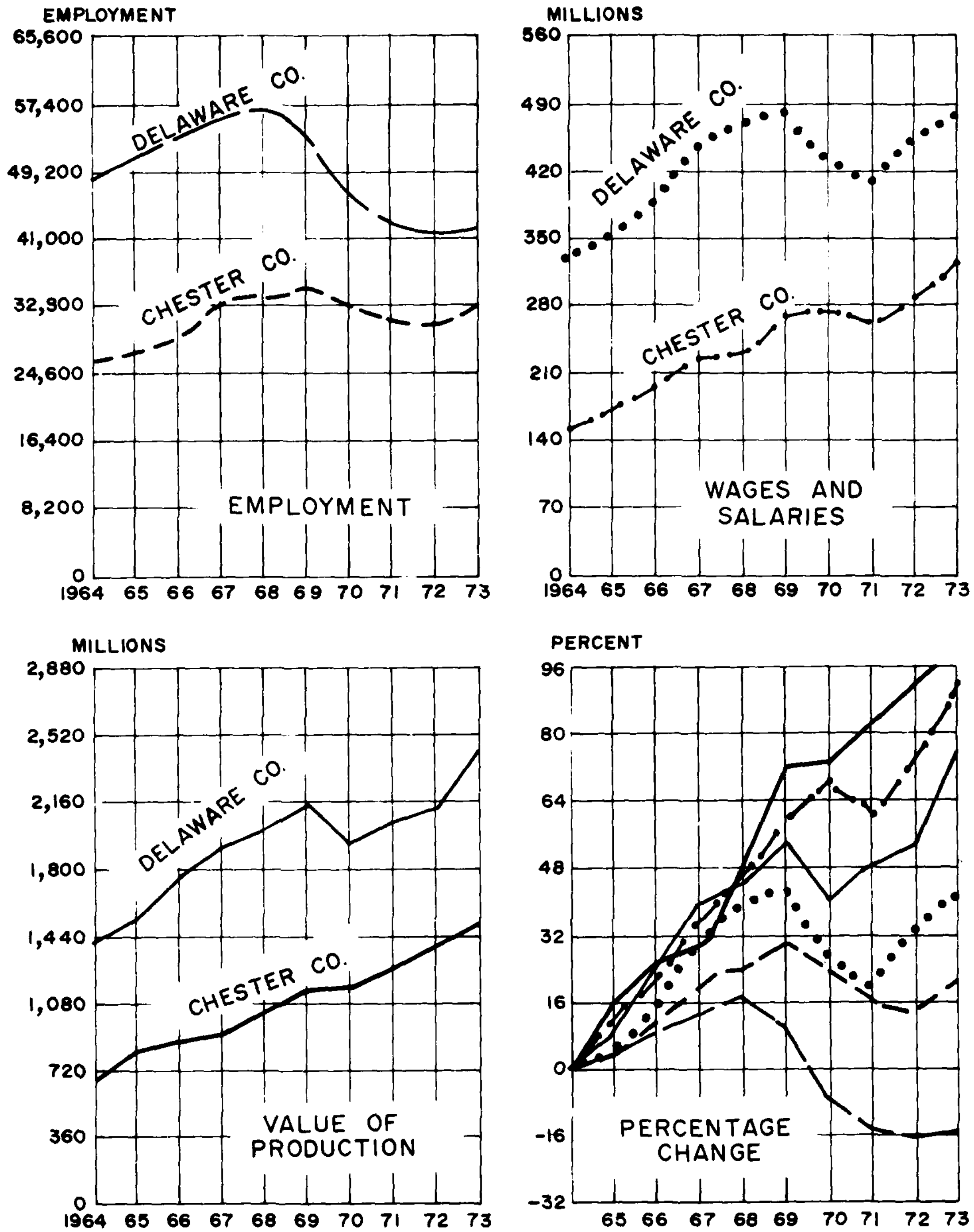



CHESTER CREEK BASIN, PENNSYLVANIA

SCHOOL DISTRICTS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE B-9




CHESTER CREEK BASIN, PENNSYLVANIA

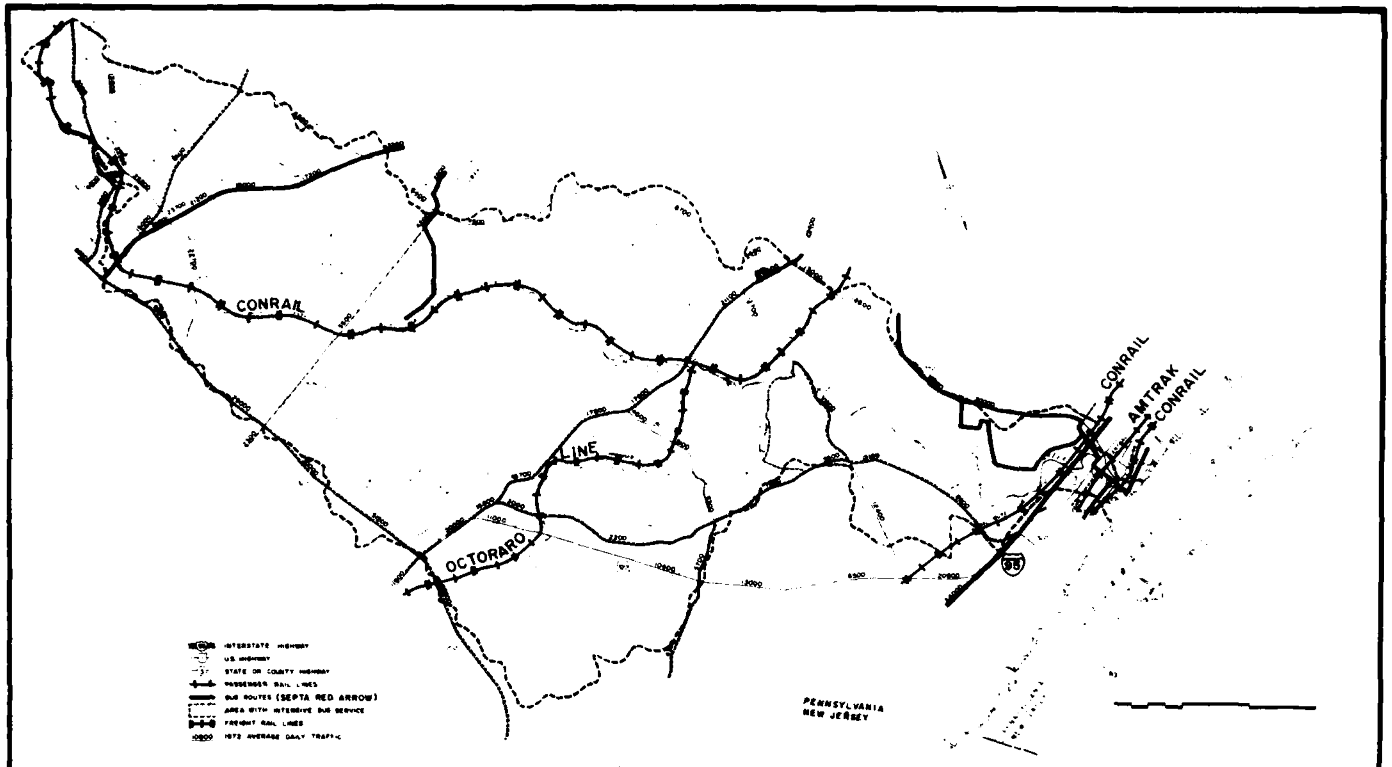
**TEN YEAR**

**COUNTY ECONOMIC REVIEW**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

PLATE B-10



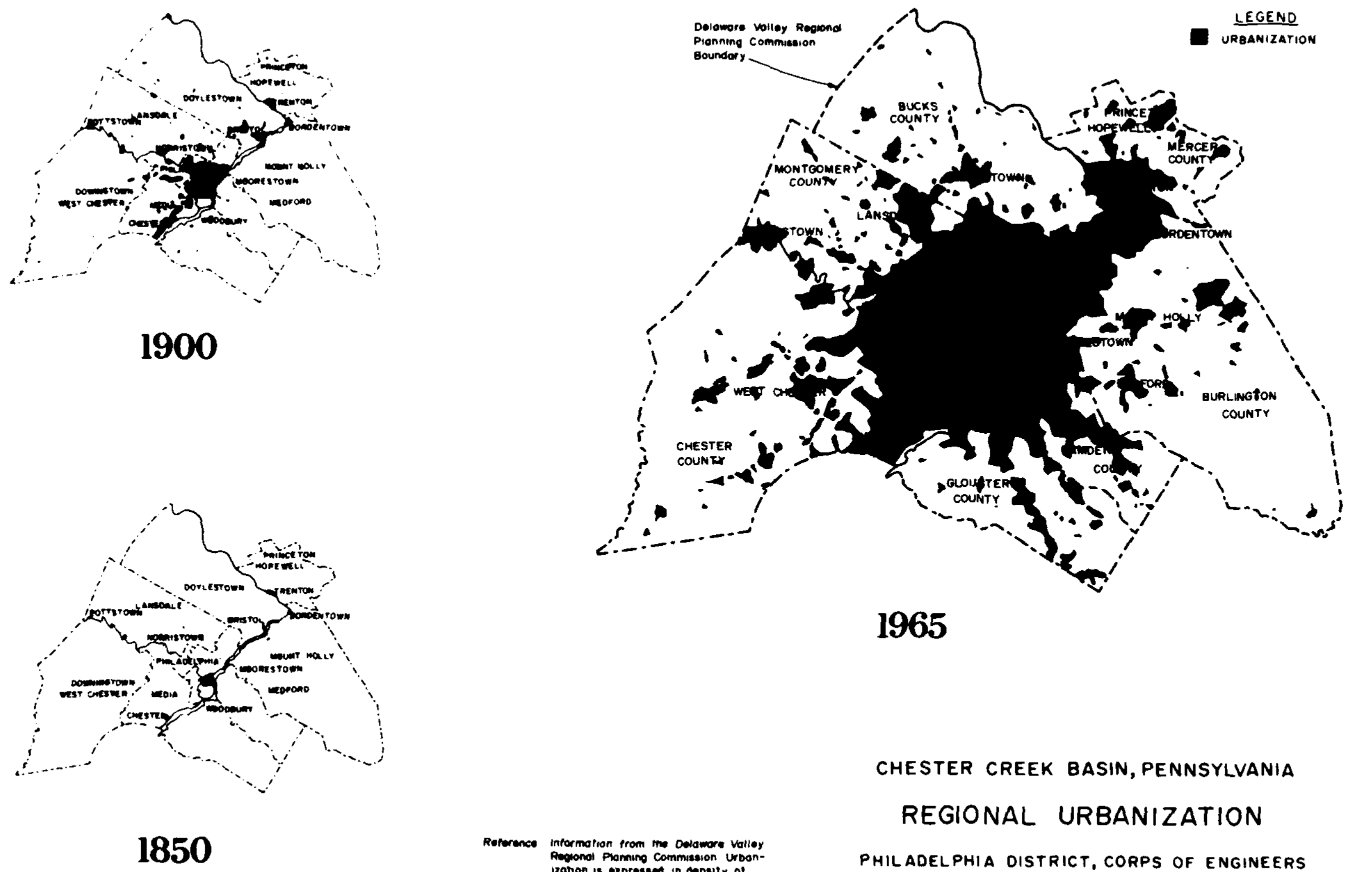

CHESTER CREEK BASIN, PENNSYLVANIA

TRANSPORTATION NETWORKS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

PLATE B-11

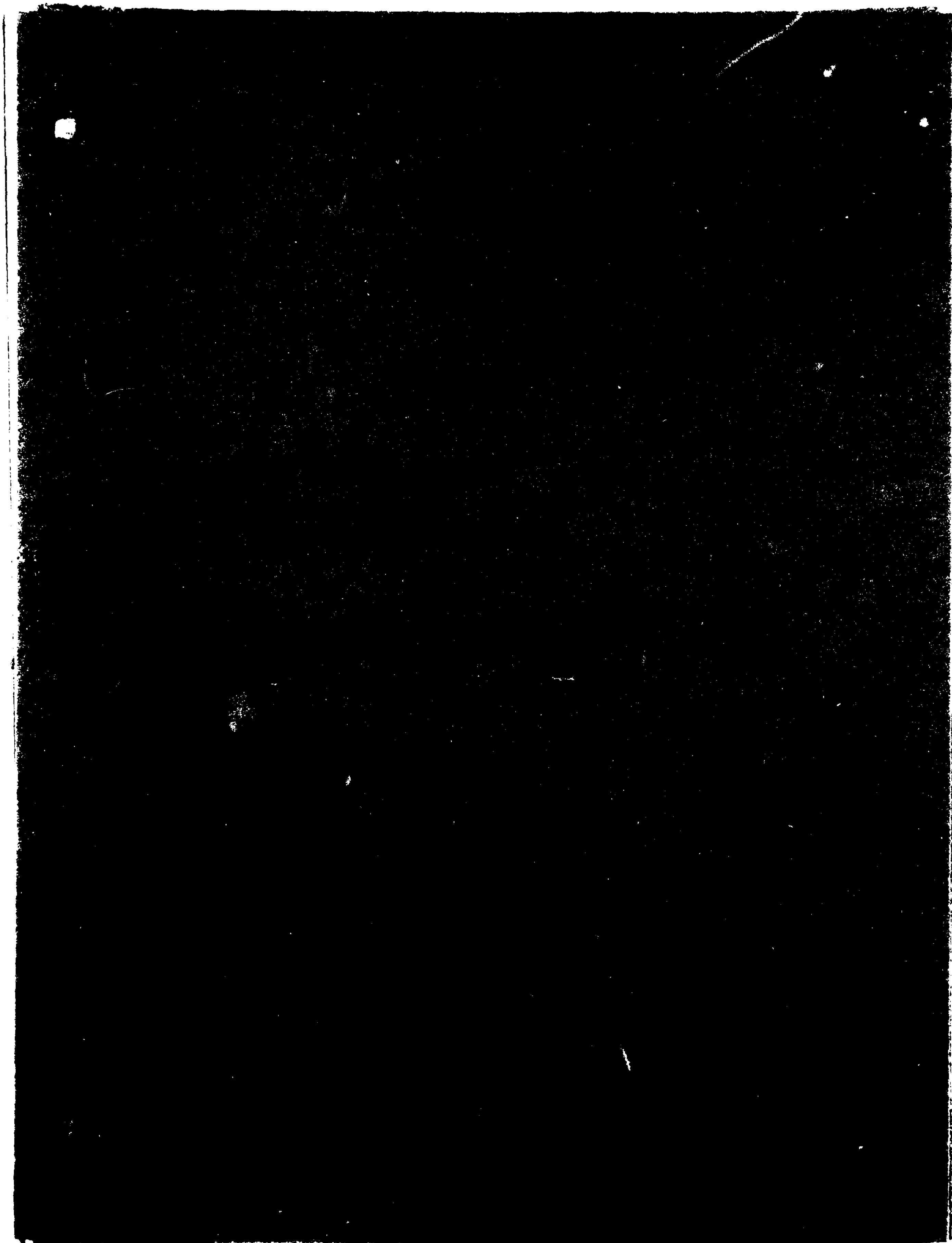


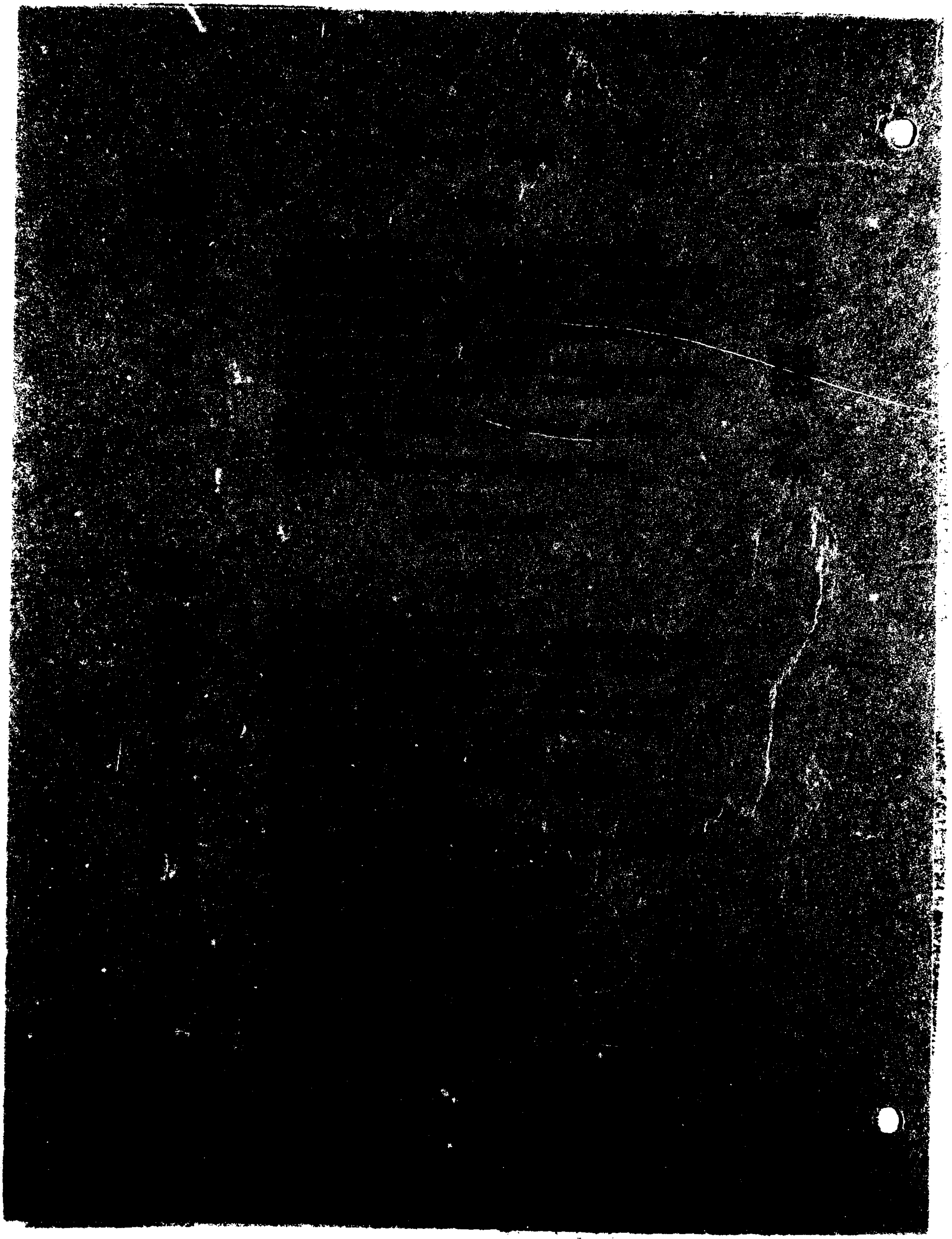

Reference: Information from the Delaware Valley Regional Planning Commission Urbanization is expressed in density of development

CHESTER CREEK BASIN, PENNSYLVANIA

REGIONAL URBANIZATION

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978





SECTION C

# PROBLEMS AND NEEDS

1. There are numerous water and non-water related problems facing the residents of the Chester Creek Basin. Rapid population growth has placed heavy demands on the ability of local governments to provide services whether in transportation, water supply, recreation, etc. These problems have been compounded by the redistribution of population from city to suburbs. The need identification portion of the study developed a listing of specific planning objectives. Once defined, the study was focused toward meeting these needs.

2. Problem identification and establishment of planning objectives was undertaken through six steps:

Identification of water resources issues

Inventory of existing water resources systems

Analysis of water resources needs

Analysis of responsibility and ability of existing and proposed institutions to resolve water resources needs.

Selection of water resources needs which can be satisfied by Corps study effort, and setting planning objectives

Quantification of needs which can be satisfied by the study.

3. In determining the water resources issues of the Basin, input of other agencies was sought and incorporated into the ultimate determination of the study's planning objectives. This coordination revealed that there was not only much concern over water resources issues in the Basin but interest in trying to find solutions. However, it was also discovered that a significant amount of study was and still is being devoted by others toward satisfying these water resources issues.

4. The five water resources and land related issues which were identified for the Basin are listed below. Information on each issue is presented in this section.

Water Quality and Wastewater Management

Water Supply

Recreation

Erosion and Sedimentation Control

Flood Water and Flood Plain Management

## WATER QUALITY AND WASTEWATER MANAGEMENT

5. The degradation of water quality in both the surface and groundwaters of the Basin has resulted primarily from the impact of man's activities on these waters. Wherever practical, the wastewater management goals for the Basin should be to provide for the treatment of point and non-point sources of pollution before the effluent can reach surface and groundwaters and to restore to a clean unpolluted condition the waters of the Basin.

### PLANNING AREA

6. Federal, State, regional, and local agencies have in the past and are presently developing plans for solving not only immediate problems but also meeting long range water quality and wastewater management needs. The Delaware County Regional Sewerage Project, completed in November 1972, considered problems and alternative solutions on a multi-county or subregional basis, while Pennsylvania's Comprehensive Water Quality Management Plan (COWAMP/208) is considering the entire southeastern portion of Pennsylvania as its planning area.

7. In this study, the water quality and wastewater management issue was not investigated within the confinement of the Chester Creek Basin but on a sub-regional level. The study area had to include the following:

Facilities or treatment systems which service portions of the Basin but are located outside the Basin's boundaries.

Facilities or treatment systems which service areas outside of the Basin but are located within the Basin's boundaries.

Plans or programs with larger study areas which include the Basin.

8. <u>SURFACE WATER</u>. Surface water is an important resource for water supply, wastewater disposal, recreation, fishing, and aesthetics.

Streamflow characteristics and water quality determine the suitability of the water for these uses. The quality of surface waters in the Basin is greatly influenced by discharges from municipal and industrial treatment facilities, combined sewer overflows, and direct overland stormwater runoff from urban, rural, and agricultural areas. The effects of these discharges vary with seasonal and meteorological conditions. Heavy precipitation increases the amount of sediment and surface pollutants entering streams, but at the same time, lowers the concentration of normal pollutants from point discharges. Although it has not been measured, the initial shock of pollutants "cleaned off" of urban, rural and agricultural surfaces by storm waters probably has a significant effect on Chester Creek's waters. Conversely, long periods without precipitation reduce quantities of sediment and surface pollutants in the streams. However, they also reduce the dilutation capacity of the stream by lowering flow. This results in increased concentrations of pollutants from point discharges.

9. Chester Creek generally exhibits satisfactory levels of dissolved oxygen (DO) during normal flow periods in spite of the large waste loads from the West Chester area. Most of the stream, however, has elevated levels of ammonia-nitrogen and nitrate-nitrogen. A steady-state simulation of Chester Creek for 1977 baseline conditions is being used by COWAMP/208. The model does not indicate that at low flows there are severe problems with respect to the average daily dissolved oxygen. Any potential problems are reduced due to the naturally high reaeration rates in the reaches below West Chester. However, oxygen levels steadily decrease downstream to the mouth of Chester Creek. This is a concern because the night DO values could drop below 4.0 mg/l, the minimum criteria for the stream. Ammonia-nitrogen below West Chester could also be a problem. If photosynthetic activity takes place and raises the pH to above 8.0 (a common occurrence in the study area), the combination of high pH and warm water temperatures will likely raise the un-ionized ammonia concentration above the established criteria of 0.02 mg/l (higher values being toxic to fish). Nitrate-nitrogen levels were also modeled at levels greater than 20 mg/l, exceeding the established criteria of 10 mg/l. It is apparent that increased levels of treatment will be required by all dischargers to meet stream standards.

10. GROUNDWATER. While not a major source of water supply in the Basin, groundwater is an important residential and commercial source in isolated parts of the upper Basin. The great dispersion of consumers and high cost for distribution lines makes the use of groundwater sources for public water supply economically infeasible. Generally, groundwater quality is superior to that of surface waters, but localized contamination does often occur. Major sources of groundwater pollution result from the percolation of pollutants from surface or near surface sources such as septic tanks, landfills, and sewers.

11. WASTEWATER POINT SOURCES. Point discharges have and still are receiving most of the attention in the Basin. The major sources of wastewater

point discharges are domestic or municipal (public) sewage effluent, on-site domestic infiltration, institutional sewage effluent, and industrial effluent. Point discharges have been identified as a greater source of pollution to surface and groundwater in the Basin than non-point sources. Fortunately, point discharges are relatively easier to monitor, establish corrective legislation for, and treat. Estimates of existing and projected wastewater flows are presented in Plate C-1. The Basin is not only undergoing intense residential and related commercial growth but also an influx of industrial park development. This trend will continue. Even though most of the planned industrial parks are for light or "clean" industries, their density is expected to create an aggregated flow comparable to some "heavier" industries.

12. Major wastewater treatment facilities are shown on Plate C-2. There are presently seven municipal treatment plants which service portions of the Basin. Two of these plants are located and discharge their effluent outside the Basin. There are ten major institutional treatment facilities and one active industrial facility in the Basin. The industrial plant discharges its effluent directly into the Delaware River.

13. PA's Comprehensive Water Quality Management Plan indicates that meeting State water quality standards will require tertiary treatment for all wastewater effluent. By the year 2020 approximately 93 to 97% Biochemical Oxygen Demand (BOD) removal from all effluents will be required. Many may even require this degree of treatment well before 2020.

14. Often on-site disposal systems are the only economical method of disposal in areas where suitable soils conditions exist and population density is low. As shown on Plate C-2, there are on-site sewage disposal problems in the Basin. Along with septic systems, small non-municipal facilities, such as those for mobile home parks and institutions, appear to be serious problems.

15. WASTEWATER NON-POINT SOURCES. Non-point sources are a major concern because of the immediate or "shock" pollution loads which may be transported into surface and groundwater systems. This currently unmeasured load may be just as critical as point sources. In the Chester Creek Basin, urban runoff contributes a considerable amount of the total pollution to surface waters. Stormwater drainage systems exist primarily in the more established, older and denser Basin communities as shown on Plate C-2. These are areas of the greatest land surface accumulation of inorganic debris and wastes; dust and dirt; fecal droppings from domestic and non-domestic animals; oil; exhaust residue; etc. Much of the urban stormwater is collected and transmitted by drainage systems to receiving waters. Many of the systems in the Basin are combination storm and sanitary systems where sanitary wastes are diverted to treatment plants. However, during storms, the stormwater and raw sewage flow in these combined drainage systems is often bypassed directly to receiving surface waters.

16. Pollution from rural and agricultural runoff is not as great a problem as urban runoff. In fact, existing rural and agricultural runoff problems are being lessened by urbanization. Refuse dumps and landfills are suspected of contributing to groundwater pollution by leachate percolation. Another unmeasured source of contamination comes from sewer line exfiltration; especially, from the older sewerage systems. Another source of groundwater contamination in the lower Basin is intrusion of salt water from the Delaware River. During drought conditions the normal salt line in the Delaware River is located upstream of the City of Chester. The overpumpage of wells draws brackish water into the subsurface groundwater system. However, at present there is no record of this condition causing any serious problems to water supplies.

17. The most serious non-point source problem is erosion and sedimentation due to urban runoff, construction, and roadside drainage. Although current detailed information is lacking, the U.S. Geological Survey in a mid-1960's sampling program on an urban basin in the region (Cobbs Creek) frequently observed suspended solids concentrations greater than 1,000 mg/l during storm events. Increased urbanization without stormwater controls will worsen this.

18. DELCORA. In order to solve existing problems and meet projected needs, Delaware County commissioned the "Delaware County Regional Sewerage Project" study. The study was a county-wide regional wastewater management study including every stream in Delaware County. The plan which has been adopted by Delaware County is shown on Plate C-3. The plan recommends the phasing out of selected local municipal, institutional and some industrial plants and on-site systems; and transmitting flows to two regional plants by a series of interceptor sewers and forced mains. By the year 2020, approximately 60 million gallons per day (MGD) will be transmitted from 22 eastern Delaware County communities to the City of Philadelphia's Southwest Treatment Plant. Approximately 115 million gallons per day will be transmitted from the western portion of the County to the City of Chester's treatment plant. The Chester Creek Basin is included in this western portion. Both the Philadelphia and Chester plants are scheduled to be at tertiary treatment levels by the year 2020 and both will discharge directly into the Delaware River. The DELCORA plan is not controlling the non-point source problem.

19. The Delaware County plan recommends an entire implementation plan to include financing, scheduling, and management. The plan is being implemented by a regional authority, the Delaware County Regional Water Quality Control Authority (DELCORA), in cooperation with eight subregional service areas. DELCORA was officially established as an operating institution on 21 October 1971. DELCORA is presently completing its first phase of construction which includes several interceptor force mains and trunk lines connecting to the Chester City and Philadelphia Southwest Treatment Plants.

20. COWAMP/208. A draft COWAMP/208 "Report on Plans and Choices" was issued in September 1977. Selection of plans to be recommended for

implementation is currently underway. DELCORA's future plans may be altered dependening on the results of the COWAMP/208 study. The COWAMP/208 study will become part of the "State Water Plan"

## SUMMARY OF PROBLEMS AND NEEDS

21. There are many existing water quality and wastewater management problems and needs in the Basin; many which have been quantified and are being addressed and many which have not. Additional needs may be identified in the future. Many current programs and planning efforts will require supplemental efforts. Findings by the COWAMP/208 study are summarized in the following paragraph.

22. Water quality problems in the Basin have been prioritized by consideration of a number of factors:

Relationship to public health, safety and welfare

Permanence of environmental damage

Areal extent of problem

Number of people affected

Contribution of exceedence of water quality criteria

Relationship of current usage and practices of BMP (Best Management Practice)

Impact on Delaware Estuary

23. The ranking of problems and needs are as follows:

Higher levels of treatment for point sources which discharge into Chester Creek to meet low flow criteria for dissolved oxygen, nitrate-nitrogen, and un-ionized ammonia

Stormwater volume control in urban and newly developing areas to prevent threats to public health and long-lasting environmental damage

Erosion and sedimentation control of construction sites and road drainage

Quality control of sewer overflows

Prevention of widespread occurrences of residual wastes/groundwater contamination/spills which produce locally severe effects

Elimination of malfunctioning septic systems which are a public health factor, an aesthetic nuisance and a cause of increased background nutrient concentrations

Eventual elimination of minimal water quality degradation resulting from agricultural activities.

## STATUS OF EXISTING AND FUTURE PLANS

24. Municipal point source planning is being accomplished through the three-step 201 facility planning process. DELCORA was accomplished through the 201 facility planning process. As a result of DELCORA's plans, many of the existing municipal discharges have been regionalized into a county-wide system. These plans were initiated prior to 208 and are well on their way toward implementation. The COWAMP/208 plan, therefore, incorporated these DELCORA studies. Plans for the upper Chester Creek watershed are being reviewed by COWAMP/208 in light of new population projections in Chester County and alternative approaches to point source management. Point source technical alternatives currently being investigated by COWAMP/208 include:

Land application of wastewater treated to the secondary level from individual treatment plants

Stream discharge of wastewater from individual treatment plants

Stream discharge of wastewater from a subcentral arrangement of treatment plants

Non-sewered approach.

25. The COWAMP/208 Study has investigated alternative plans to control these sources of pollution. Plans include not only technical measures to control pollution, but also management procedures and institutional, financial, and regulatory arrangements necessary to carry them out. With intense urbanization, the assimilative capacities of some of these surface waters may also require treatment of major non-point pollution sources in order to meet quality standards of surface waters.

26. One of the point source alternatives will be selected as the recommended plan and will be presented in Chapter XIII of the COWAMP/208 report which is scheduled for transmittal to the Governor of Pennsylvania for approval in mid 1978. This report will also include recommendation for disposal or reuse of sludge (landfilling, land spreading, incineration), for control of pollution from intermittent point and non-point sources, and for management of the wastewater facilities.

## STUDY OBJECTIVES

27. DER is responsible for the development and coordination of regional water quality and wastewater management plans for the entire Commonwealth of Pennsylvania. Pennsylvania has assumed responsibility for needed water quality and wastewater management planning in the Chester Creek Basin. The Commonwealth indicated that it was addressing water quality and wastewater management problems in the Chester Basin. The Chester Creek Basin Study did not investigate the water quality and wastewater management needs nor did the Corps' study perform any portion of the COWAMP/208 Study effort. However, there has been a continuous flow of information and coordination between these studies in order to avoid duplication of effort and insure compatability.

28. This study did include assessment of the impact on the quality of surface and groundwaters for each floodwater and flood plain management alternative which was considered. Consideration has been given to appropriate Federal, State and regional objectives and criteria in evaluating the impacts on water quality. Specific consideration has been given to "The Clean Streams Law" (Act 394 approved 22 June 1937, as amended) of the Commonwealth of Pennsylvania, which sets forth the objective of preventing further pollution of the State waters and cleaning up those that are polluted.

## WATER SUPPLY

29. Much of the demand for water from users in the Chester Creek Basin is satisfied by supply sources outside the Basin. The outside sources utilized incluce not only water transfers from other sub-basins within the Delaware River Basin but also one transfer from the Octoraro Creek Watershed which lies within the Susquehanna River Basin. Conversely, Chester Creek's water is transferred to users located outside the Basin. An established allocation of water is transferred directly into the Ridley Creek. Chester Creek water is also transferred indirectly into the Christina River Basin in Delaware State through distribution by a supplier to its customers in the West Chester area. These customers are located outside of the Chester Creek Basin's boundary. Satisfying water supply problems and needs of the Chester Creek Basin will, therefore, require the consideration of the entire water supply network within which it is included.

## PLANNING AREA

30. The Pennsylvania Department of Environmental Resources (DER) is presently developing water supply plans as part of its Pennsylvania "State Water Plan." For planning purposes, the Chester Creek Basin is included in SUB-BASIN 3G shown on Plate C-4. This area includes Chester Creek, Ridley Creek, Crum Creek, Darby Creek, other contiguous areas draining directly into the Delaware River, and the Delaware River itself. WATERSHED 3G has an area of 244 square miles, with most of the area lying in Delaware and Chester Counties.

| Basin | Chester County (sq. miles) | Delaware County (sq. miles) | Total (sq. miles) |
|---|---|---|---|
| Chester Creek | 22 | 45.9 | 67.9 |
| Ridley Creek | 18 | 20.8 | 38.8 |
| Crum Creek | 12.7 | 25.8 | 38.5 |
| Darby Creek* | 6.9 | 59.2 | 77.9* |
| Others | 0 | 20.9 | 20.9 |
| TOTAL | 59.6 | 172.6 | 244.0* |

* Includes 11.8 square miles in Montgomery and Philadelphia Counties.

31. PUBLIC WATER SUPPLY. The major suppliers are public utility or municipal suppliers. There are four major suppliers, the Philadelphia Suburban Water Company, the Chester Water Authority, the Media Municipal Water Works, and the Borough of West Chester Municipal Authority. The service areas of these water suppliers are shown on Plate C-4. Only the last three of the suppliers listed actually service consumers in the Chester Creek Basin. Table C-1 presents information on the service area population, supply sources, and facilities of these four suppliers which service almost one million consumers. Those consumers include not only residential users but also commercial, industrial, and agricultural. The per capita use rates for the four suppliers range from 97 to 227 gallons per capita per day. The extremely high per capita rate of 227 gallons per day for the Chester Water Authority is attributed to the fact that 50% of their useage is to supply industrial users. Reserve storage capacity of treated water ranges from about 1.6 to 3.6 days of storage. All of the suppliers' service areas are about 90 to 100 percent metered. A percentage breakdown of water use is shown in the following tabulation:

| | Phila. Sub. Water Co. | Chester Water Auth. | Media Mun. Water Works | West Chester Mun. Auth. |
|---|---|---|---|---|
| Residential | 61% | 18% | 73% | 59% |
| Commercial | 13 | 5 | 7 | 0 |
| Industrial | 10 | 49 | 2 | 25 |
| Other | 2 | 1 | 4 | 15 |
| Bulk Sales | 0 | 12 | 0 | 0 |
| Leaks or Loss | 13 | 15 | 14 | 1 |

## TABLE C-1
## PRINCIPAL WATER SUPPLIERS 1/ 2/
## WATERSHED 3G

| Supplier | Population Served | Average Daily Water Use (MGD) 3/ | Sources | Treatment Plant Capacity (MGD) 3/ | Treated Water Storage (MG) 4/ | Days of Supply |
|---|---|---|---|---|---|---|
| Philadelphia5/ Surburban Water Co. | 759,175 | 74.011 | 18 Wells<br>7 Surfaces Sources | 91.500 | 124.100 | 1.677 |
| Chester Water Authority | 114,836 | 29.615 | 3 Wells<br>1 Reservoir<br>1 Surface | 45.000 | 105.000 | 3.546 |
| Media Municipal Water Works | 31,046 | 3.402 | 1 Well<br>2 Surfaces | 8.000 | 5.490 | 1.614 |
| West Chester Municipal Authority | 25,689 | 2.991 | 8 Wells<br>2 Reservoirs<br>1 Surface | 4.500 | 5.000 | 1.672 |

1/ Information based on calender year 1970 use data.
2/ Draft data; therefore, subject to revision. SOURCE: Pennsylvania Department of Environmental Resources - State Water Plan.
3/ MGD indicates million gallons per day.
4/ MG indicates millions gallons.
5/ Does not supply consumers in the Chester Creek Basin.

## TABLE C-2
## ADEQUACY OF PUBLIC WATER SUPPLY 1/
## WATERSHED 3G

| Supplier | Yield Deficiency (MGD) 3/ 2020 | Allocation Deficiency (MGD) 2020 | Treatment Plant Deficiency (MGD) 2020 | Storage Deficiency (MGD) 2020 | Critical Year | Deficiency Causing Critical Point |
|---|---|---|---|---|---|---|
| Philadelphia Sub-Urban Water Co. 2/ | (54.000) 4/ | (60.700) | (65.900) | (24.000) | 1980 | Treatment plant capacity & yield |
| Chester Water Authority | None | (8.832) | (21.024) | None | 1985 | Treatment plant capacity |
| Media Municipal Water Works | (6.441) | (5.907) | (3.993) | (3.128) | 1977 5/ | Yield and allocation |
| West Chester Municipal Authority | None | (3.736) | (6.907) | (4.210) | 1985 | Treatment plant capacity & then storage |

1/ Draft data; therefore, subject to revision. SOURCE: Pennsylvania Department of Environmental Resources - State Water Plan.
2/ Does not supply consumers in the Chester Creek Basin. Included entire service area beyond SUB-BASIN 3G.
3/ MGD indicates million gallons per day.
4/ Brackets indicate deficiencies or negative quantities.
5/ 1977 was projected to be the critical year for water supply based on the safe yield from all sources. Since a drought did not occur in 1977, the availabe supply exceeded the safe yield and no shortage occurred.

32. Present supplies are not adequate to meet future needs. An indication of the ability to meet future needs is the ratio of supply to demand which is summarized below. A supply divided by demand ratio below unity(1) indicates that needs cannot be met with existing or planned future sources.

| Year | Phila. Sub. Water Co. | Chester Water Auth. | Media Mun. Water Works | West Chester Mun. Auth. |
|---|---|---|---|---|
| 1970 | 1.271* | 2.179 | 1.653 | 5.262 |
| 1980 | 1.028 | 1.693 | 1.292 | 3.919 |
| 1990 | 0.874 | 1.451 | 1.043 | 2.968 |
| 2000 | 0.775 | 1.320 | 0.873 | 2.386 |
| 2020 | 0.635 | 1.149 | 0.653 | 1.709 |

* Supply divided by demand ratios are unpublished, therefore, subject to revision. SOURCE: Pennsylvania Department of Environmental Resources.

33. A more in-depth presentation of the long range adequacy of the existing public water supply network in the Chester Creek Basin is presented in Table C-2. As noted in the table, under drought conditions water supply shortages could occur **in the very near future.** These projected shortages present a very serious situation in light of the fact that major public works projects average a seven to ten year development period. Fortunately these adverse conditions have not yet (1977) materialized. The inadequacies are not entirely the result of deficiencies in sources of water. Deficiencies in yields and allocations at the source, as well as treatment plant capacities, may also limit the ability to meet future needs. The projected 1977 and 1980 water supply shortages are both partly the result of deficiencies in yield at the water source.

34. SELF-SUPPLIED WATER SUPPLY. Self-supplied domestic and institutional consumers are usually supplied by on-site wells. Industry (including power plants) and agriculture obtain water by direct surface water withdrawals. Most of the large users of water are located along the banks of the Delaware River. Therefore, most of their needs are satisfied by surface water withdrawals from the Delaware River.

35. SURFACE WATERS. Consumers in Sub-Basin 3G use mostly surface waters to meet their needs. Water storage sites have been and still are being eliminated by the very types of development (residential, commercial, and industrial) which require the production of additional water. Reservoir projects are being hindered because of environmental reasons. Some of the smaller streams have a considerable portion of their total flows made up of municipal and industrial waste treatment plant effluents. These streams are considered unsuitable as sources of water supply. The Delaware River, which could provide the required quantity of water, not only has a water pollution problem but also a salinity problem during periods of drought. Because of this inability to use Delaware River water, the Chester Water Authority has been utilizing since 1951 transfers from Octoraro Creek in the Susquehanna River Basin. Major

regional reservoirs which could be located outside WATERSHED 3G, but would help meet the sub-basin's needs are either behind schedule or there is a serious question that they will ever be constructed. This problem compounds the water supply situation by postponing or eliminating expected sources.

36. GROUNDWATERS. WATERSHED 3G lies predominantly within the Piedmont Province physiographic region which is underlain by dense, hard crystalline rocks. The upper layers of these crystalline rock formation are cracked and fissured. Groundwater flowing through these fissures offers very low yield potential. Yields generally do not exceed 10 gallons per minute, making wells unsuitable to supply densely populated or commercial areas. Wells are used as individual domestic sources. Quantity and quality of water from these wells vary considerably. In some areas, quantity and quality are not sufficient during periods of peak demand. It is often necessary to remove objectionable quantities of iron in order to soften the water for usage. An additional problem is that contamination of groundwater also takes place through the leaching of landfills. Some groundwater sources are contaminated and are considered unsuitable until their quality can be upgraded. Regardless of the quality aspect, groundwater because of its low yield potential, cannot meet the demands of today's intensive residential and commercial developments.

## SUMMARY OF PROBLEMS AND NEEDS

37. The people of the Chester Creek Basin have existing needs for the development of dependable sources of water supply. Water supply problems and needs are listed below:

Existing sources are insufficient to meet future water supply requirements. Although all of the municipalities and their water purveyors are seeking additional sources of water supply, water shortages are predicted to occur within this decade.

Locating and developing major reservoir sites is difficult because of urbanization and environmental considerations. Major multipurpose reservoirs which include water supply and low flow augmentation storage are either behind schedule or will not be constructed. Natural land areas suitable for impoundment sites have been developed, thereby making them economically and socially infeasible as potential reservoir sites.

The Delaware River Basin Commission (DRBC) as a general policy does not favor requests for interbasin transfers of water. Such requests have been refused until all possible inter-basin resources are totally developed. There is a need for studies of this alternative method of providing water, as well as other possible water sources such as water renovation or reuse, flood skimming, and groundwater recharge.

Several water suppliers experienced significant system leaks and other losses. Studies are needed to determine how these losses can be reduced.

## STATUS OF EXISTING AND FUTURE PLANS

38. Although water supply planning to some degree is being conducted by all municipalities and/or their water purveyors, the major effort in a regionalized approach to the water supply problems in WATERSHED 3G is currently being undertaken by DER in the "State Water Plan." Alternative solutions to water supply problems are being formulated by DER. These solutions not only include development of additional sources and facilities but also more efficient management of existing sources and future demands. The State Water Plan's draft report on Sub-Basin 3 was completed in September 1977 and the final report is scheduled for completion in 1978.

## STUDY OBJECTIVES

39. DER is responsible for the development of comprehensive water supply plans for the entire Commonwealth of Pennsylvania. This effort has been initiated for WATERSHED 3G, through the "State Water Plan." Following a series of meetings, and detailed discussions of the "State Water Plan" and the opportunities available through the Chester Creek Basin Study, the Commonwealth of Pennsylvania has indicated that it is responsible for a regional approach for water supply planning in the Chester Creek Basin. The Commonwealth indicated that it is addressing water quality in the Basin.

40. The Chester Creek Basin Study did not include any water supply studies per se and did not perform any portion of the "State Water Plan" effort. Although multi-purpose potential, including flood control, water supply, and water related recreation was initially considered, it was obvious that water supply storage could only be developed at the expense of flood control storage. This was due to the limited storage potential at available reservoir sites and high level of flood protection needed. Because of constraints to developing reservoirs, single purpose dry reservoirs were identified as the only way to achieve a satisfactory level of flood protection. No further consideration of water supply storage took place. However, there was a continuous flow of information between the "State Water Plan" effort and the Chester Creek Basin Study.

# RECREATION

41. The types of recreation considered in this study included not only water based recreation, but also related land recreation which may be developed in conjunction with a water resources project or program. Examples of related land recreation would be development of bicyle paths, hiking trails, or picnic areas in conjunction with dry reservoirs, levees, or flood plain management.

42. With increasing leisure time for an increasing population, recreational demands of the people of the Chester Creek Basin continue to grow. At the same time, urbanization eliminates open spaces; thereby, reducing opportunities for recreation. Recreational development must be understood in the light of long-term land use patterns that occur with the growth of the region.

## PLANNING AREA

43. Recreational and open spaces needs of the study area can not be totally satisfied within the confines of the Chester Creek Basin. Because of the size, complexity, or investment required for certain recreational activities, facilities must be designed to satisfy the needs of a number of other areas. These facilities must be planned on a regional basis. The Pennsylvania Department of Environmental Resources (DER) is presently examining recreation needs as part of its "State Water Plan"*. For planning purposes, the Chester Creek Basin is included in Sub-Basin 3. This area incorporates Bucks, Chester, Delaware, Montgomery, Philadelphia and Berks Counties and is the planning area for presentation of needs.

44. Plate C-5 shows the existing recreational facilities in the 6 county DER planning area as well as neighboring New Castle County, Delaware. Most recreation by Basin residents which takes place outside of these seven counties takes place in the Pocono Mountains in northeastern Pennsylvania and at the seashore in southern New Jersey. Plate C-6 shows existing parks and recreation areas in the Basin. Most of the areas are small municipal or private facilities. The larger facilities are owned by either the county or State.

* State Water Plan only addresses water and related land resources. The Pennsylvania "State Recreation Plan" (formerly the State Comprehensive Outdoor Recreation Plan) addresses the problems and needs of all outdoor recreation activities in Pennsylvania.

45. FACILITIES IN DELAWARE COUNTY. There are about 2,555 acres of state park and recreation land in Delaware County. None of these areas lie in the Chester Creek Basin. State recreation areas are large multi-purpose facilities serving large populations from many service areas, and provide for extended stays as well as day outings. The goal is to provide state parks within 25 miles of every resident of the Commonwealth.

46. Delaware County acquires and develops parks and open spaces throughout the county. The primary functions of these areas are to protect and enhance the environment through conservation of outstanding natural features and to provide facilities to meet the needs of its residents. County parks are designed to serve smaller population and to be located within about 5 miles of the population served. Until 1964 most County park land had been acquired as gifts from estates or individuals. In 1964 the State activated a program, Project 70, to assist counties and municipalities in the acquisition of open space land. Delaware County is in the process of enlarging two existing parks and creating five new parks. The county has acquired all or portions of the land creating two new parks and enlarging one existing park.

47. Municipal parks and open lands provide for the needs and use of the residents of that municipality. Because of the differences in the characters of municipalities in Delaware County, their uses vary. In general, the more densely populated municipalities have more highly developed park and recreation systems. Uses range from tot-lots and golf courses to land conservation. Municipal parks usually serve a particular neighborhood and help maintain a balance of open space with densely populated areas. Municipal facilities include playfields for football, baseball, or hockey; game courts for basketball, tennis, volleyball; picnic areas; playground equipment; and open general purpose fields.

48. FACILITIES IN CHESTER COUNTY. Until recently, Federal involvement in recreation and open spaces in Chester County consisted of the Soil Conservation Service's Brandywine Creek Watershed Work Plan. The Brandywine Creek Basin is located west of the Chester Creek Basin. One floodwater retarding dam and two multi-purpose dams including storage for flood control, water supply and recreation have already been constructed. The multi-purpose dams have permanent pools of 125 acres and 535 acres. They provide areas for picnicking; power and non-power boating; and hiking. One additional multi-purpose dam and several flood prevention dams remain to be installed under the plan. Federal involvement was increased in December 1977 with the transfer of historic Valley Forge State Park (2494 acres) to the National Park Service. This National Historic Park already provides picnicking, camping and fishing.

49. There are five state parks and game lands in Chester County totalling 2179 acres. French Creek State Park, the largest State park in Chester County, provides picnicking, camping, swimming, boating and fishing. There are four county parks in Chester County. These provide 1,567 acres of open lands. These lands are operated by the Chester County Parks and

Recreation Board. They offer various combinations of recreational opportunities. Municipal parks in Chester County provide for the need of residents of a municipality. Municipal parks are generally many and well distributed throughout Chester County, but are not numerous in the Chester Creek Basin portion of the county.

50. There are large tracts of institutional and private land in Chester County that in total area far exceed public lands. Many of these tracts are partially available for general public use. These institutions make a major contribution to recreation and open space lands of Chester County. Included in these tracts are arboretums, conservancies and museums. In addition, many thousands of acres of farm land are made available during the fall and winter hunting seasons without any cost to the public.

## SUMMARY OF PROBLEMS AND NEEDS

51. There will be increased demands on existing recreation facilities in the future. Not only will this include the larger type facilities but also those traditionally provided by municipalities in the Basin. WATERSHED 3G which includes the Chester Basin, does not have sufficient facilities to meet these demands. Table C-3 provides a capsulization of the supply and demand for water resources related recreation facilities. There is an immediate need for picnic and beach facilities. By 1990 there will also be a need for additional areas for power boating and fishing. As shown on Table C-4, many municipalities will not be able to meet recreation demands. This problem will become worse as urbanization and population densities increase.

## STATUS OF EXISTING AND FUTURE PLANS

52. There are a number of on-going planning efforts for recreation and open space development which are considering the needs of all or part of the Chester Creek Basin. The major efforts are being conducted by DER, DVRPC, and Delaware and Chester Counties.

53. DER, in its "State Recreation Plan," has inventoried recreation and open space areas in the Commonwealth; has prepared recreation plans for the Commonwealth; and has formulated planning alternatives and recommendations.

54. The Delaware Valley Regional Planning Commission (DVRPC) is also undertaking recreational studies. DVRPC considers recreational and open space needs on a municipal basis but within the confines of a county and sub-region. DVRPC has prepared an interim open space plan for the Delaware Valley Region. That plan has identified recreation and open space needs and outlined ways of meeting the needs to year 1985. This

TABLE C-3

RECREATIONAL SUPPLY AND DEMAND
WATERSHED 3G 1/

| ACTIVITY | UNITS | DEMAND 1970 | DEMAND 1990 | DEMAND 2020 | SUPPLY 1970 | NEEDS 1970 | NEEDS 1990 | NEEDS 2020 |
|---|---|---|---|---|---|---|---|---|
| Picnic | Tables | 2,920 | 3,630 | 4,260 | 1,480 | 1,440 | 2,190 | 2,780 |
| Beach | Lin. Ft. | 100 | 200 | 200 | 0 | 100 | 200 | 200 |
| Pool | Sq. Ft. | 197,000 | 263,000 | 307,000 | 341,000 | 0 | 0 | 0 |
| Power Boating | Acres | 2,886 | 4,220 | 5,275 | 2,886 | 0 | 1,534 | 2,389 |
| Non-Power Boating | Acres | 1,242 | 2,898 | 2,898 | 2,898 | 0 | 0 | 0 |
| Fishing | Yearly Man-Days (Thousands) | 411 | 606 | 711 | 508 | 0 | 98 | 203 |

1/ SOURCE: Pennsylvania State Water Plan, September 1977 draft on Sub-basin 3. Watershed 3G is the subdivision of Sub-basin 3 which contains the Chester Creek Basin.

TABLE C-4

EXISTING AND PROJECTED
LOCAL RECREATION NEEDS
CHESTER CREEK BASIN MUNICIPALITIES 1/

| MUNICIPALITIES | 1970 LOCAL ACREAGE NEEDS | 1985 LOCAL ACREAGE NEEDS | ABILITY TO MEET NEEDS FROM FAMILY INCOME | LOCAL NEEDS |
|---|---|---|---|---|
| DELAWARE COUNTY | | | | |
| Aston Township | Very High (more than 40 acres) | Very High (more than 90 acres) | Can Not Meet Needs | Critical |
| Bethel Township | High (15 to 39 acres) | High (25 to 89 acres) | May Meet Needs | Critical |
| Birmingham Township | Low (less than 4 acres) | Moderate (5 to 24 acres) | May Meet Needs | Moderate |
| Brookhaven Township | High (15 to 39 acres) | High (25 to 89 areas) | Can Not Meet Needs | Very Critical |
| Chester City | Very High (more than 40 acres) | Very High (more than 90 acres) | Can Not Meet Needs | Very Critical |
| Chester Heights Borough | Low (less than 4 acres) | Moderate (5 to 24 acres) | May Meet Needs | Critical |
| Chester Township | High (15 to 39 acres) | High (25 to 89 acres) | Can Not Meet Needs | Very Critical |
| Concord Township | High (15 to 39 acres) | Very High (more than 90 acres) | May Meet Needs | Critical |
| Edgmont Township | Low (less than 4 acres) | Very High (more than 90 acres) | May Meet Needs | Critical |
| Middletown Township | Very High (more than 40 acres) | Very High (more than 90 acres) | Can Not Meet Needs | Critical |
| Parkside Borough | High (15 to 39 acres) | High (25 to 89 acres) | May Meet Needs | Very Critical |
| Thornbury Township | Moderate (5 to 14 acres) | Moderate (5 to 24 acres) | May Meet Needs | Moderate |
| Upland Borough | High (15 to 39 acres) | High (25 to 89 acres) | May Meet Needs | Very Critical |
| Upper Chichester Township | Moderate (5 to 14 acres) | High (25 to 89 acres) | May Not Meet Needs | Critical |
| CHESTER COUNTY | | | | |
| Birmingham Township | Low (less than 4 acres) | Low (less than 5 acres) | May Meet Needs | Moderate |
| East Goshen Township | High (15 to 39 acres) | Very High (more than 90 acres) | May Not Meet Needs | Critical |
| Thornbury Township | Low (less than 4 acres) | Moderate (5 to 24 acres) | Can Meet Needs | Moderate |
| West Goshen Township | Very High (more than 40 acres) | Very High (more than 90 acres) | May Meet Needs | Critical |
| West Chester Borough | Very High (more than 40 acres) | Very High (more than 90 acres) | May Not Meet Needs | Very Critical |
| Westtown Township | High (15 to 39 acres) | High (25 to 89 acres) | Can Meet Needs | Critical |
| West Whiteland Township | Very High (more than 40 acres) | Very High (more than 90 acres) | May Meet Needs | Critical |

1/ SOURCE: Delaware Valley Regional Planning Commission

is being updated as part of the Year 2000 planning process which is to be completed in mid-1978.

55. Delaware County and Chester County planning commissions have inventoried existing recreation and open spaces in their counties and have identified areas for preservation. These inventories are revised periodically to keep them current. A draft report "Delaware County Open Space, Park, and Recreation Study" was issued in 1975 and a final report will be completed in 1978. This study recommends a program of acquisition and development over a ten year period with the expenditures allocated as follows:

| Years | 1976-78 | 1979-80 | 1981-85 |
|---|---|---|---|
| Major County Parks Acquisition and Facilities Development | 90% | 70% | 30% |
| Stream Valley Acquisition | 10% | 30% | 70% |

56. The Pennsylvania Wild and Scenic River Study has proposed that a 15 mile stretch of Chester Creek between Cheyney and Upland be classified as a Recreational River. A Recreational River is a river which is readily accessible, that may have some development along its banks and may have undergone some impoundment or diversion in the past.

## STUDY OBJECTIVES

57. DER is responsible for the development of comprehensive recreation and open space plans for the entire Commonwealth of Pennsylvania. DER has initiated efforts in WATERSHED 3G which includes the Chester Creek Basin. Following a series of meetings, and detailed discussions on the opportunities available through the Chester Creek Study, the Commonwealth of Pennsylvania indicated that it is responsible for a regional approach for needed recreational and open space planning in the Chester Creek Basin. The Commonwealth indicated that it is addressing recreation and open space problems in the Basin.

58. The Chester Creek study did not include studies of the development of recreation plans for the Basin. However, the study did investigate the possibility of recreational or open space development in conjunction with flood control projects and programs. Recreational development was considered at dry reservoirs, local channel and levee/floodwall plans, and flood plain evacuation. Local officials and planning agencies identified need of more of a local nature. The study therefore considered needs on a county basis (Chester and Delaware Counties) but with emphasis on individual municipalities.

# EROSION AND SEDIMENTATION CONTROL

59. In the Chester Creek Basin, both erosion of upstream land and sedimentation in streams affect many other water resources issues including: the aesthetic quality of water; the in-stream bio-chemical process of photosynthesis; the cost for water treatment; the storage capacity of reservoirs; the floodwater and transport capacity of streams; the navigation capacity of channels; the loss of valuable land; and the support and stability of structures. It was evident that these problems should be a component of any water resources investigation of the Chester Creek Basin.

## PLANNING AREA

60. The planning area is the Chester Creek Basin. Chester Creek has a long history of erosion and sedimentation problems. The Creek's annual sedimentation rate is one of the highest of all tributaries of the Delaware River. Conditions present in the Chester Creek Basin which promote high erosion and sedimentation rates are: gently rolling hills with some steep hills and narrow valleys; and the easily erodable soils of the Piedmont Province. According to the Delaware River Basin Report (H.D. 522, 87th Congress, 2d Session), the Chester Creek has an estimated annual sediment yield of 265 tons per square mile which results in 17,490 tons of sediment per year.

61. In the Delaware Valley Region approximately 50 to 60% of total precipitation either evaporates, transpires, or is consumed before it reaches the surface water or groundwater systems. Of the remainder, about 20 to 25% infiltrates into the groundwater system and about 20 to 25% flows directly into streams. Sheet erosion, which is usually the main cause of stream sedimentation, washes away soil particles by the flow of water over the land surface. The deposition of the erodible materials occurs either in the transporting or receiving waters. Another major cause of land erosion and stream sedimentation is excessive stormwater or flooding. Since urbanization will continue to occur, the potential for erosion and sedimentation problems is expected to grow accordingly.

62. <u>SCS AND COUNTIES</u>. The Soil Conservation Service and the Counties have been concerned with soil erosion, mostly to save agricultural lands. A major objective of the County Conservation Districts is to develop and implement conservation plans for the protection of land and water resources. These plans are developed under cooperative agreements with the landowners and may incorporate sediment and erosion control measures.

The Soil Conservation Service provides staff expertise and assistance including preparation of the conservation plans.

63. PENNSYLVANIA DER. More recently, concern has centered on erosion due to land development. Pennsylvania's Clean Streams Law stated that sedimentation resulting from erosion is a pollutant. Under the law DER regulates development for purposes of erosion and sediment control. DER regulations require that all persons engaged in earth moving activities must design, implement and maintain sedimentation and erosion control plans for the project area. However, only those projects involving 25 or more acres require a DER permit prior to commencement of the activity. One of the major causes of erosion and sedimentation in the Chester Creek Basin is urbanization activity involvement less than 25 acres. Enforecement of DER regulations for this work is difficult due to lack of a permit requirement. Traditionally, regulation of land development is the responsibility of municipalities, and effective programs are generally lacking.

## SUMMARY OF PROBLEMS AND NEEDS

64. Erosion and sedimentation problems are related to the other water resources issues. Erosion and sedimentation problems should be considered jointly with the investigations of those issues. A summary of generalized problems and needs in the Basin are as follows:

> Sedimentation is one of the greatest water quality contaminants in the Chester Creek Basin. Disease germs, pecticides, and other pollutants attach themselves to the sediment particles and are transported throughout the Basin. Actual measurement of this phenomenon has not been conducted, but its potential effects may be considerable because of high sediment movement measured in the Chester Creek.
>
> Siltation of streams and impoundments has reduced their surface water storage capacities.
>
> Surface and bank erosion reduce the land's potential productivity. This results in not only direct monetary losses to the land's uses but also community losses in tax bases.

## STATUS OF EXISTING AND FUTURE PLANS

65. There are no planning activities which are primarily concerned with the erosion and sedimentation problems of the Chester Creek Basin.

66. The Commonwealth of Pennsylvania's "Comprehensive Water Quality Management Plan" (COWAMP/208) is concerned with sedimentation but not as a primary study purpose. In the COWAMP study sedimentation will be considered under the category of non-point sources of pollutants. (Additional information on this is included under Water Quality and Wastewater Management in this Section.)

## STUDY OBJECTIVES

67. DER is responsible for the development of comprehensive erosion and sedimentation plans in the Chester Creek Basin. Following a series of meetings, and detailed discussions on the opportunities available through the Chester Creek Basin Study, the Commonwealth of Pennsylvania indicated that it would assume responsibility for any needed erosion and sedimentation control studies in the Basin. The Chester Creek Study, therefore, considered erosion and sedimentation control problems only where they are related to the floodwater and flood plain management planning objectives of this study.

# FLOODWATER AND FLOOD PLAIN MANAGEMENT

68. Both overbank and localized stormwater backup have been constant problems in the Chester Creek Basin. The frequency of localized minor flooding and the potential for major flooding has increased with urbanization taking place in the Basin.

## PLANNING AREA

69. The great majority of the flooding problems in the Basin result from overbank flooding. However, stormwater drainage problems are also present. For the purpose of this study the planning area was the Chester Creek Basin, except where existing storm drainage system extends beyond this natural drainage area.

70. The hilly topography of land in the Chester Creek Basin lends itself to fast runoff, though the soil conditions lend themselves to permeation to the aquifers below. In some areas the ground cover is heavy and evapotranspiration is great. In the more urbanized areas, vegetative cover is almost nonexistent and water runs off the surface quickly. Because the Basin is either urban or urbanizing, drainage generally takes the form of overland flow to street gutters and then storm sewer flow directly to streams. In the semirural areas of the Basin overland flow goes directly to the stream.

71. Plate C-7 shows the extent of major storm sewer systems in the

basin. There are still many developed areas which do not have storm sewer systems. Many of the storm sewers, particularly in the lower portion of the Basin, were not designed for the urban area that they actually serve; therefore, their design capacities have been frequently surpassed and there are flooding problems. Channeled and culverted streams have become inadequate due to increased development.

72. The flooding problems in the lower 2 miles of the Chester Creek become compounded when high tides in the Delaware River occur simultaneously with runoff produced from intense rainfall. The main tidal range on the Chester Creek at its mouth is about 6.0 feet, varying from a mean low tide elevation of about -2.4 feet below mean sea level (MSL) to a mean high tide elevation of about +3.6 feet MSL. The highest tide on record was greater than +8 feet MSL and occurred in August 1933. However, there have been no instances of high tides by themselves causing flooding problems.

73. Flooding is greater in areas where obstruction such as bridges with inadequate channel openings or encroachments restrict the passage of flood flows. There are presently 26 bridges over the Chester Creek in the ten miles of main stem reaches which have suffered the greatest damages. Most of these bridges restrict flood flows. Other major constructions which are common in these same high damage areas are encroachments by dumps, landfills, and structures. These bridges and encroachments increase localized backwater and result in greater damages than would have occurred if they were not there.

74. <u>CHARACTERISTICS OF FLOODING</u>. Flooding has occurred in the Basin since the time of its earliest settlement in 1643. However, flooding did not become a problem until actual development in the flood plain took place. Stream flow data has been recorded by the U.S. Geological Survey since 1932. Damages from overbank flooding in the lower reaches begin to occur when flows at the Dutton Mill Road stream gage reach about 4,000 cubic feet per second (cfs). In the 46 years, 13 events have exceeded 4,000 cfs. Information on these events, as well as other probable events,are listed in Table C-5. Plate C-8 shows the discharge-frequency curve at the gage. Appendix 1, Section E (Hydrologic Studies) provides information on the magnitude of flood flows at other locations in the Basin. Plate C-9 shows the limits of the SPF*, 100-year, and 25 year flood plains in the lower reaches. Appendix 1, Section F (Hydraulic Studies) provides data on flood heights and velocities for both the lower reaches and the Goose Creek Watershed.

75. The average annual damages in the Basin are approximately $720,300 (January 1978 price level) based on existing conditions. Data on the distribution of these damages over various damage reaches and also over various frequency events is included in Appendix 1, Section H (Benefit

* SPF is the Standard Project Flood, a rare event. See Appendix 1, Section E for further explanation.

Analysis). An approximate breakdown of existing average annual damages by community is shown below:

| Municipality | Distribution of Average Annual Damages* | Average Annual Damages |
|---|---|---|
| Aston Township | 8% | $ 56,200 |
| Brookhaven Borough | 1 | 6,600 |
| Chester Heights Borough | 2 | 14,500 |
| Chester Township | 11 | 77,200 |
| City of Chester | 28 | 205,600 |
| West Chester Borough & West Goshen Township (Goose Creek Basin) | 18 | 133,900 |
| Middletown Township | 17 | 121,500 |
| Upland Borough | 15 | 104,800 |
| Total | 100% | $720,300 |

* Average annual damages were computed for only major damage reaches. Other scattered damages do exist throughout the Basin.

76. As indicated in Table C-5, flooding in the Chester Creek Basin usually occurs as a result of local heavy rains during the summer and fall of the year. These storms produce high creek stages in a short time. This flash flooding situation is the product of a relatively long narrow basin with steep slopes. Stormwater which cannot be absorbed by the soil runs off quickly into the stream, and flood stages develop when the capacity of the channel is exceeded. The resulting overbank flood flow is carried downstream by the flood plain.

77. In the flood problem areas considered in this study the flood plain areas for the 100-year and SPF events are shown below:*

| | Chester Creek (acres) | West Br. Chester Creek (acres) | Goose Creek (acres) | Total (acres) |
|---|---|---|---|---|
| 100-Year | 585.2 | 6.4 | 89.6 | 681.2 |
| SPF | 721.8 | 8.4 | 98.7 | 828.9 |

78. Flood depths are great. As can be seen from Table C-5 the 100-year flood is about 13 feet above the zero damage elevation. The SPF event would have flood depths of about 19 feet above zero damage elevation. Second-story flooding has occurred in the Basin.

* This is not the total area (acres) of all flood plains in the Basin. It is only the area within the major damage reaches.

TABLE C-5
CHARACTERISTICS OF FLOODING
CHESTER CREEK

| Flood Event | Type of Storm 1/ | Flow at Gage (cfs) 2/ | Elevations (ft.) 3/ | Damages 4/ |
|---|---|---|---|---|
| SPF | NA | 35,800 | 54.0 | $26.9 M |
| 13 Sept. 71 | HR | 21,000 | 48.0 | 17.6 |
| 100-YEAR EVENT (1%) | NA | 20,300 | 47.5 | 16.2 |
| 50-YEAR EVENT (2%) | NA | 16,000 | 44.8 | 6.5 |
| 25 Nov. 50 | HR | 14,400 | 43.7 | 4.6 |
| 25-YEAR EVENT (4%) | NA | 11,900 | 41.8 | 2.6 |
| 12-13 Sept. 60 | TS | 9,940 | 40.0 | 1.6 |
| 28 July 69 | HR | 9,560 | 39.7 | 1.4 |
| 18-19 Aug. 55 | TS | 9,380 | 39.5 | 1.3 |
| 10-YEAR EVENT (10%) | NA | 8,090 | 38.4 | 0.9 |
| 23-24 Aug. 33 | TS | 6,250 | 36.7 | 0.5 |
| 22-23 June 72 | TS | 6,180 | 36.6 | 0.5 |
| 23 July 38 | HR | 5,120 | 35.4 | 0.2 |
| 9-10 Jan. 36 | HR | 5,000 | 35.2 | 0.2 |
| 3 Aug. 50 | HR | 5,000 | 35.2 | 0.2 |
| 15 Mar. 67 | HR | 4,770 | 34.9 | 0.1 |
| 7 Mar. 67 | HR | 4,730 | 34.8 | 0.1 |
| 1 Aug. 45 | HR | 4,440 | 34.7 | 0.1 |
| Approximate Discharge causing Damages from Over-bank Flooding in Lower Reaches | | 4,000 | | 0.0 |
| Mean Annual Discharge | | 1,300 | | 0.0 |

1/ Symbols denote the following: NA is Not Applicable; HR is Heavy Rainfall; and TS is Tropical Storm.
2/ Discharges measured at the Dutton Mill Gage which is a United States Geological Survey water-stage record. Gage records exist from 1932. Discharge is measured in cubic feet per second (cfs).
3/ Elevations are in feet above mean sea level and are measured at the Dutton Mill Gage.
4/ Damage estimates are in January 1978 millions of dollars (M). These are damages which would occur if the flood occurred under 1977 Basin conditions.

79. Common land development practices near Chester Creek transform existing streams and their tributaries from natural hydrologic systems to components of a man-made drainage system. Natural banked streams are piped or lined. These masonry mazes are periodically overloaded when their designs are exceeded. These overloaded systems not only cause nuisance drainage problems but also major flooding with significant damages. The flood scenario in the Basin is becoming one of the combination of overbank flooding of open portions of streams; backing up and overtopping of inclosed portions of streams or interceptors; and a general pooling of water because of the inability of both the natural and man-made drainage system to transport stormwater. Plate C-7 shows the existing storm sewer service areas as well as the urban drainage problem areas.

80. FLOOD OF RECORD. The magnitude of flooding problems of the Basin can best be expressed by discussion of the magnitude and scope of the effects of the flood of record which occurred on 13 September 1971. This flood was caused by a very localized rainfall which did not affect adjacent basins. This flood was slightly larger than the 1 percent chance flood (100-year). Almost every community in the Basin suffered some damages from overbank flooding. Approximately 130 businesses and 732 homes were flooded. Second story flooding was common. The Corps of Engineers levee and floodwall project at Eyre Park was overtopped by six to eight feet. There were eight deaths. One fireman drowned during rescue operations. The assistant pastor of a local church drowned while performing volunteer rescue work. One woman was swept off of a road bridge and another from a road. A woman drowned when a rescue boat tipped over. A man and his wife drowned when their car was swept off a bridge and submerged. Another man drowned when he left his stalled car on a bridge. The Chester Water Authority was forced to close down its water supply treatment plant for 5 days and a "boil water" order was issued.

81. Total flood costs estimated to have occurred during the September 1971 flood (in January 1978 dollars) were as follows:

| | |
|---|---|
| Residential | $ 6,286,000 |
| Commercial and Industrial | 17,029,000 |
| Utilities | 177,000 |
| Highway | 795,000 |
| Public | 515,000 |
| Flood Emergency | 1,336,000 |
| TOTAL | $ 26,138,000 |

82. FLOOD DAMAGES. The locations of major damage centers in the Basin are shown on Plate C-10. Most of the major damages occur in the lower reaches of Chester Creek and along Goose Creek in West Chester. The damage sub-reaches with most of the damages are delineated in Plate C-11. These are sub-reaches 1A through 18F in the lower portion of the Basin and 51A through 55 in the upper portion. A complete inventory of these damage sub-reaches is presented in Plates C-13 through C-28 at the end of Section C. These plates show the location of each damage unit and the category of damage. For commercial and industrial units addresses are also shown.

83. Flood damage information (tangible flood costs) was developed by sub-reach, damage category and type. For reporting and comparative purposes the damages are segregated according to the following: residential (structural and contents); commercial/industrial (structural and contents); and others. Every reach does not necessarily contain all of these categories and types of flood damages.

84. Damage-Frequency data is presented in Table C-6 for selected levels of flooding. About 96 percent of the total probable damages in the Basin (up to SPF event) occur in the lower reaches (1A-18F). About 80 percent of the total probable damages occur in 3 communities: City of Chester, Borough of Upland and Chester Township. Of the total probable damages in these 3 communities about 53 percent occur in the City of Chester, 30 percent in the Borough of Upland, and 17 percent in Chester Township.

85. Major damages in the lower reaches (1A-18F) do not begin to accrue until the 25-year level of flooding; but the damages increase rapidly with increasing stages of flooding. In the upper reaches (51A-55) a relatively constant growth of damages is experienced from the onset as early as a 10-year event.

86. Table C-5 presents approximate total damages for reconstructed historic flooding events. This indicates what damages would be incurred if those events would occur today. The 10, 25, and 50-year and SPF events are included for reference and comparison. It can be seen from this table that the flood of record was almost five times greater than any other previously recorded event. It can also be seen that most of the other historic floods were relatively minor in total scope. However, it should be kept in mind that just as the potential for disaster of these historic events has grown since the time when they actually occurred so is this potential expected to grow in the future. This is primarily due to expected increases of stormwater runoff from continued urbanization (land development).

87. Table C-7 presents the damage distribution by damage categories for the 50 and 100-year floods. This shows that residential contents are about 38% of total residential damages and about 12% of total damages. Total residential damages are about one-third of total damages. Commercial and industrial contents are about 42% of all damages in the Basin and total commercial and industrial damages make up about 60% of all damages. Other categories are only one-twentieth of the total damages.

88. The density distribution of damages for the 100-year and Standard Project Flood are presented in Table C-8. This shows the high damage concentration areas. Flood plain areas for both the 100-year event and the SPF are also listed for each sub-reach.

89. Intangible flood damages cannot be predicted to occur as a result of a future flooding event, as can be done for tangible costs. The

TABLE C-6
DAMAGES BY CATEGORY FOR SELECTED FREQUENCIES
CHESTER CREEK BASIN 1/

| Sub-Reaches | Categories 2/ | 10-Year | 25-Year | 50-Year | 100-Year | SPF |
|---|---|---|---|---|---|---|
| | | (thousand dollars) | | | | |
| 1A, 1B, 2A, 2B | C/I (C) | 0 | 0 | 0 | 219.65 | 322.02 |
| | C/I (S) | 0 | 0 | 2.43 | 45.39 | 136.63 |
| | R (C) | 0 | 0 | 0 | 9.72 | 35.93 |
| | R (S) | 0 | 0 | 0 | 11.56 | 45.57 |
| | O (S) | 0 | 0 | 6.00 | 379.08 | 900.08 |
| | Subtotal | 0 | 0 | 8.43 | 665.40 | 1440.23 |
| 3A, 3B, 4A, 4B | C/I (C) | 0 | 0 | 250.42 | 775.29 | 1116.40 |
| | C/I (S) | 0 | 0 | 65.50 | 255.62 | 458.40 |
| | R (C) | 0 | 0 | 9.31 | 30.40 | 116.03 |
| | R (S) | 0 | 0 | 9.53 | 42.32 | 129.08 |
| | O (S) | .22 | 2.09 | 33.81 | 184.64 | 302.79 |
| | Subtotal | .22 | 2.09 | 368.57 | 1288.27 | 2122.70 |
| 4C, 4D, 5A, 5B | C/I (C) | 0 | 0 | 49.99 | 1564.47 | 1897.78 |
| | C/I (S) | 0 | 0 | 18.49 | 378.26 | 556.13 |
| | R (C) | 0 | 0 | 68.15 | 183.65 | 348.25 |
| | R (S) | 0 | 1.75 | 70.49 | 210.20 | 354.20 |
| | O (S) | 0 | 0 | 29.12 | 199.62 | 338.29 |
| | Subtotal | 0 | 1.75 | 236.24 | 2536.20 | 3494.65 |
| 6A, 6B, 6C, 7A, 7B | C/I (C) | .31 | 33.17 | 186.73 | 994.30 | 1359.15 |
| | C/I (S) | .42 | 21.87 | 251.10 | 1096.46 | 1549.17 |
| | O (S) | 0 | 1.91 | 22.17 | 115.57 | 256.02 |
| | Subtotal | .73 | 56.95 | 460.00 | 2206.33 | 3164.34 |
| 8A, 8B | C/I (C) | .05 | 26.02 | 204.76 | 326.75 | 418.77 |
| | C/I (S) | .02 | 5.43 | 11.70 | 39.78 | 96.94 |
| | R (C) | 31.44 | 72.07 | 147.51 | 266.80 | 557.64 |
| | R (S) | 23.58 | 92.00 | 220.03 | 400.39 | 290.81 |
| | O (S) | 0 | 3.67 | 36.46 | 146.01 | 246.04 |
| | Subtotal | 55.09 | 199.19 | 620.46 | 1179.73 | 1610.21 |
| 9A, 9B, 9C, 9D | C/I (C) | 1.34 | 63.51 | 263.22 | 765.01 | 1173.67 |
| | C/I (S) | 2.68 | 44.46 | 120.59 | 272.52 | 510.97 |
| | R (C) | .04 | 9.13 | 84.68 | 431.27 | 1251.33 |
| | R (S) | .79 | 164.92 | 563.88 | 1350.10 | 2368.52 |
| | O (S) | 5.31 | 36.87 | 103.95 | 202.20 | 490.09 |
| | Subtotal | 10.16 | 318.89 | 1136.32 | 3021.10 | 5794.58 |
| 10A, 10B, 10C | R (C) | 62.14 | 203.80 | 480.95 | 820.48 | 1998.88 |
| | R (S) | 38.83 | 150.05 | 376.73 | 755.66 | 1629.39 |
| | O (S) | 0 | 2.51 | 7.76 | 23.06 | 146.64 |
| | Subtotal | 100.97 | 356.36 | 865.44 | 1599.20 | 3774.91 |
| 11A, 11B, 11C, 11D, 11E | C/I (C) | 0 | 0 | 5.83 | 79.27 | 163.72 |
| | C/I (S) | 0 | 0 | .32 | 6.35 | 98.83 |
| | R (C) | 0 | 0 | 16.57 | 65.20 | 135.62 |
| | R (S) | 0 | 0 | 16.83 | 59.06 | 122.18 |
| | O (S) | 2.60 | 7.61 | 17.26 | 53.11 | 175.11 |
| | Subtotal | 2.60 | 7.61 | 56.81 | 262.99 | 695.46 |
| 12A, 12B, 12C 12D, 13A, 13B, 13C, 13D | C/I (C) | 36.84 | 53.01 | 58.64 | 64.97 | 86.82 |
| | C/I (S) | 9.08 | 19.77 | 26.98 | 30.79 | 40.07 |
| | O (S) | 0 | .92 | 17.42 | 89.54 | 286.22 |
| | Subtotal | 45.92 | 73.70 | 103.04 | 185.30 | 413.11 |

TABLE C-6 (Continued)

| Sub-Reaches | Categories 2/ | 10-Year | 25-Year | 50-Year | 100-Year | SPF |
|---|---|---|---|---|---|---|
| | | (thousand dollars) | | | | |
| 14, 15A, 15B, 15C, 15D, 15F | C/I (C) | 0 | 93.66 | 172.06 | 193.69 | 264.66 |
| | C/I (S) | 0 | 147.97 | 349.39 | 432.69 | 526.47 |
| | R (C) | 0 | .39 | 2.70 | 4.67 | 14.24 |
| | R (S) | 0 | 4.91 | 8.58 | 10.63 | 20.57 |
| | O (S) | 4.40 | 7.82 | 14.30 | 26.55 | 79.49 |
| | Subtotal | 4.40 | 254.75 | 547.03 | 668.23 | 905.43 |
| 16A, 16B, 16C, 16W | C/I (C) | 244.55 | 575.48 | 982.09 | 1176.88 | 1446.86 |
| | C/I (S) | 63.44 | 179.25 | 301.02 | 365.39 | 495.20 |
| | O (S) | 26.93 | 41.64 | 62.33 | 77.81 | 127.13 |
| | Subtotal | 334.92 | 796.37 | 1345.44 | 1620.08 | 2069.19 |
| 17A, 17B, 18A, 18B, 18C, 18D, 18E, 18F | C/I (C) | 38.99 | 74.77 | 78.69 | 91.12 | 137.54 |
| | C/I (S) | 19.57 | 27.54 | 35.33 | 41.93 | 105.83 |
| | R (C) | 4.61 | 6.74 | 14.11 | 23.11 | 31.20 |
| | R (S) | 4.27 | 7.78 | 10.18 | 14.37 | 24.08 |
| | O (S) | 0 | .26 | 3.62 | 19.11 | 67.27 |
| | Subtotal | 67.44 | 117.09 | 141.93 | 189.64 | 363.92 |
| Subtotal 1A-18F | C/I (C) | 322.08 | 919.62 | 2252.43 | 6263.04 | 8410.99 |
| | C/I (S) | 95.21 | 446.29 | 1182.85 | 2990.78 | 4620.94 |
| | R (C) | 98.23 | 292.13 | 823.98 | 1821.50 | 4428.06 |
| | R (S) | 67.47 | 421.41 | 1276.25 | 2828.69 | 4878.60 |
| | O (S) | 39.46 | 105.30 | 354.20 | 1516.30 | 3415.17 |
| | Subtotal | 622.45 | 2184.75 | 5889.71 | 15420.31 | 25754.29 |
| 51A, 51B | C/I (C) | 2.43 | 2.91 | 4.38 | 6.83 | 16.68 |
| | C/I (S) | .26 | .52 | 1.43 | 2.08 | 4.40 |
| | R (C) | 1.95 | 2.97 | 4.66 | 6.09 | 9.19 |
| | R (S) | 22.14 | 33.28 | 47.90 | 59.04 | 83.76 |
| | Subtotal | 26.78 | 39.68 | 58.37 | 74.04 | 114.03 |
| 52A, 52B | C/I (C) | 124.28 | 201.96 | 256.34 | 310.71 | 354.73 |
| | C/I (S) | 58.26 | 73.80 | 90.62 | 104.87 | 141.12 |
| | R (C) | 1.04 | 12.69 | 21.10 | 30.16 | 45.31 |
| | R (S) | 10.36 | 30.55 | 42.85 | 50.49 | 66.80 |
| | Subtotal | 193.94 | 319.00 | 410.91 | 496.23 | 607.96 |
| 53A, 53B, 54A, 54B, 55 | C/I (C) | 40.00 | 64.48 | 136.37 | 182.02 | 270.97 |
| | C/I (S) | 11.52 | 18.25 | 21.19 | 37.29 | 60.32 |
| | R (C) | 7.76 | 8.93 | 12.04 | 14.63 | 27.58 |
| | R (S) | 12.69 | 13.72 | 16.18 | 19.68 | 36.51 |
| | Subtotal | 71.97 | 105.38 | 185.78 | 253.62 | 395.38 |
| Subtotal 51A-55 | C/I (C) | 166.71 | 269.35 | 391.08 | 499.56 | 642.37 |
| | C/I (S) | 70.04 | 92.56 | 119.23 | 144.23 | 205.84 |
| | R (C) | 10.75 | 24.59 | 37.81 | 50.88 | 82.08 |
| | R (S) | 45.19 | 77.55 | 106.94 | 129.20 | 187.07 |
| | O (S) | 0 | 0 | 0 | 0 | 0 |
| | Subtotal | 292.69 | 464.05 | 655.06 | 823.87 | 1117.36 |
| Total 1A-55 | C/I (C) | 488.79 | 1188.97 | 2643.51 | 6762.60 | 9053.36 |
| | C/I (S) | 165.25 | 538.85 | 1302.08 | 3135.01 | 4826.78 |
| | R (C) | 108.98 | 316.72 | 861.79 | 1872.38 | 4510.14 |
| | R (S) | 112.66 | 498.90 | 1383.19 | 2957.89 | 5065.67 |
| | O (S) | 39.46 | 105.30 | 354.20 | 1516.30 | 3415.17 |
| | Total | 915.14 | 2648.80 | 6544.77 | 16244.18 | 26871.12 |

1/ 1977 level of development; January 1978 dollars.

2/ C/I (C) = Commercial/Industrial (Contents)
C/I (S) = Commercial/Industrial (Structure)
O (S) = Other (Structure)
R (C) = Residential (Contents)
R (S) = Residential (Structure)

TABLE C-7
DISTRIBUTION OF DAMAGES BY CATEGORY
50- AND 100-YEAR FLOODS
CHESTER CREEK BASIN 1/

| Sub-Reaches | Category 2/ | Amount 3/ | Category 4/ (percent) | Total (percent) |
|---|---|---|---|---|
| 50-YEAR FLOOD | | | | |
| 1A to 18F | C/I (C) | 2252.43 | 65.6 | 38.2 |
| | C/I (T) | 3435.28 | - | 58.3 |
| | R (C) | 823.98 | 39.6 | 14.0 |
| | R (T) | 2080.23 | - | 35.3 |
| | O (T) | 354.20 | - | 6.0 |
| | C/I(C)+R(C) | 3076.41 | - | 52.2 |
| | Subtotal | 5889.71 | - | - |
| 51A to 55 | C/I (C) | 391.08 | 76.6 | 59.7 |
| | C/I (T) | 510.31 | - | 77.9 |
| | R (C) | 37.81 | 26.1 | 5.8 |
| | R (T) | 144.75 | - | 22.1 |
| | O (T) | 0.00 | - | 0.0 |
| | C/I(C)+R(C) | 428.89 | - | 65.5 |
| | Subtotal | 655.07 | | |
| 1A to 55 | C/I (C) | 2643.51 | 67.0 | 40.4 |
| | C/I (T) | 3945.59 | - | 60.3 |
| | R (C) | 861.79 | 38.4 | 13.2 |
| | R (T) | 2244.98 | - | 34.3 |
| | O (T) | 354.20 | - | 5.4 |
| | C/I(C)+R(C) | 3503.30 | - | 53.5 |
| | Total | 6544.77 | - | - |
| 100-YEAR FLOOD | | | | |
| 1A to 18F | C/I (C) | 6263.04 | 67.7 | 40.6 |
| | C/I (T) | 9253.82 | - | 60.0 |
| | R (C) | 1821.50 | 39.2 | 11.8 |
| | R (T) | 4650.19 | - | 30.2 |
| | O (T) | 1516.30 | - | 9.8 |
| | C/I(C)+R(C) | 8084.54 | - | 52.4 |
| | Subtotal | 15420.31 | - | - |
| 51A to 55 | C/I (C) | 499.56 | 77.6 | 60.6 |
| | C/I (T) | 643.79 | - | 78.1 |
| | R (C) | 50.88 | 28.3 | 6.2 |
| | R (T) | 180.08 | - | 21.9 |
| | O (T) | 0.00 | - | 0.0 |
| | C/I(C)+R(C) | 550.44 | - | 66.8 |
| | Subtotal | 823.81 | | |
| 1A to 55 | C/I (C) | 6762.60 | 68.3 | 41.6 |
| | C/I (T) | 9897.61 | - | 60.9 |
| | R (C) | 1872.61 | 38.8 | 11.5 |
| | R (T) | 4830.27 | - | 29.7 |
| | O (T) | 1516.30 | - | 9.3 |
| | C/I(C)+R(C) | 8634.98 | - | 53.2 |
| | Total | 16244.18 | - | - |

1/ 1977 level of development; January 1978 dollars.
2/ C/I (C) = Commercial/Industrial (Contents); P (C) = Residential (Contents); C/I (T) = Commercial/Industrial (Total); R (T) = Residential (Total); O (T) = Other (Total).
3/ Amount of damages in thousands of dollars.
4/ Contents damages as a percent of total damages.

TABLE C-8
DENSITY AND DAMAGE FOR
100-YEAR AND SPF FLOOD PLAINS
CHESTER CREEK BASIN 1/

| Sub-Reaches | 100-Year Flood Plain | | SPF Flood Plain | |
|---|---|---|---|---|
| | Area 2/ (acres) | Damage ($1000/acre) | Area 2/ (acres) | Damage ($1000/acre) |
| 1A | 13.9 | 14.5 | 20.9 | 23.5 |
| 1B | 3.6 | 8.8 | 15.7 | 4.2 |
| 2A | 4.9 | 75.9 | 5.6 | 142.0 |
| 2B | 1.8 | 32.2 | 4.8 | 18.0 |
| 3A | 4.1 | 32.4 | 6.5 | 36.9 |
| 3B | 6.0 | 145.7 | 7.2 | 182.8 |
| 4A | 4.3 | 44.7 | 6.2 | 52.6 |
| 4B | 2.7 | 33.0 | 5.9 | 30.2 |
| 4C | 1.9 | 29.7 | 3.8 | 34.2 |
| 4D | 5.5 | 0.0 | 7.9 | 5.4 |
| 5A | 8.0 | 14.4 | 8.6 | 28.8 |
| 5B | 14.9 | 161.1 | 15.3 | 207.7 |
| 6A | 5.2 | 187.0 | 5.8 | 221.6 |
| 6B | 23.1 | 21.7 | 23.1 | 33.9 |
| 6C | 11.2 | 31.7 | 15.7 | 32.8 |
| 7A | 6.8 | 55.4 | 8.8 | 65.2 |
| 7B | 6.7 | 0.0 | 9.9 | 0.9 |
| 8A | 13.9 | 60.2 | 17.5 | 107.6 |
| 8B | 10.8 | 31.8 | 17.2 | 29.3 |
| 9A | 25.0 | 5.4 | 28.9 | 10.6 |
| 9B | 32.4 | 64.9 | 40.9 | 99.8 |
| 9C | 13.8 | 1.3 | 13.8 | 2.9 |
| 9D | 20.9 | 36.6 | 25.3 | 54.0 |
| 10A | 38.8 | 0.2 | 62.7 | 0.4 |
| 10B | 12.7 | 93.9 | 20.8 | 140.3 |
| 10C | 15.2 | 26.1 | 24.6 | 39.8 |
| 11A | 6.2 | 0.0 | 10.1 | 0.4 |
| 11B | 8.3 | 2.1 | 13.6 | 3.4 |
| 11C | 13.5 | 4.7 | 18.3 | 6.6 |
| 11D | 14.0 | 1.2 | 18.8 | 3.8 |
| 11E | 11.3 | 14.6 | 13.3 | 34.0 |
| 12A | 8.0 | 0.2 | 9.4 | 1.7 |
| 12B | 9.2 | 7.0 | 9.2 | 11.0 |
| 12C | 11.5 | 4.0 | 11.5 | 17.5 |
| 12D | 9.9 | 0.5 | 9.9 | 2.2 |
| 13A | 4.4 | 9.0 | 4.4 | 10.9 |
| 13B | 8.5 | 0.0 | 8.5 | 0.6 |
| 13C | 4.6 | 0.5 | 4.6 | 2.0 |
| 13D | 14.5 | 0.4 | 14.5 | 0.8 |
| 14 | 76.2 | 8.5 | 76.2 | 11.0 |

TABLE C-8 (Continued)

| Sub-Reaches | 100-Year Flood Plain Area 2/ (acres) | 100-Year Flood Plain Damage ($1000/acre) | SPF Flood Plain Area 2/ (acres) | SPF Flood Plain Damage ($1000/acre) |
|---|---|---|---|---|
| 15A | 3.7 | 0.2 | 3.7 | 2.5 |
| 15B | 3.4 | 0.4 | 3.4 | 5.7 |
| 15C | 9.0 | 2.0 | 9.0 | 3.9 |
| 15D | 5.7 | 0.1 | 5.7 | 1.7 |
| 15E | 0.0 | 0.0 | 0.0 | 0.0 |
| 16A | 3.5 | 132.6 | 5.0 | 120.7 |
| 16B | 2.9 | 393.5 | 3.4 | 420.6 |
| 16C | 4.1 | 1.8 | 4.1 | 2.8 |
| 16W | 3.9 | 2.7 | 3.9 | 6.1 |
| 17A | 6.2 | 2.4 | 6.2 | 15.2 |
| 17B | 4.6 | 8.5 | 4.6 | 13.6 |
| 18A | 15.6 | 8.3 | 15.6 | 11.3 |
| 18B | 7.1 | 0.5 | 7.1 | 1.5 |
| 18C | 7.1 | 0.0 | 7.1 | 0.5 |
| 18D | 2.5 | 0.6 | 2.5 | 2.6 |
| 18E | 0.7 | 0.5 | 0.7 | 4.2 |
| 18F | 3.4 | 0.5 | 3.4 | 1.9 |
| 51A | 5.2 | 3.9 | 5.7 | 4.8 |
| 51B | 31.5 | 1.7 | 34.7 | 2.5 |
| 52A | 7.4 | 0.2 | 8.1 | 0.4 |
| 52B | 24.7 | 20.1 | 27.2 | 22.3 |
| 53A | 0.5 | 0.0 | 0.6 | 0.0 |
| 53B | 6.2 | 21.7 | 6.8 | 29.5 |
| 54A | 1.5 | 0.0 | 1.7 | 0.0 |
| 54B | 5.1 | 11.6 | 5.6 | 16.4 |
| 55 | 7.5 | 8.0 | 8.3 | 12.4 |
| BASIN TOTALS & AVERAGES | 681.2 | 23.8 | 828.9 | 32.4 |

1/ Damages based on 1977 level of development and January 1978 dollars.
2/ All areas are approximate since detailed flood plain mapping is not available.

occurrence of intangible damages is more sensitive to circumstances at the time of the flooding event than tangible damages. For the same type event, in one instance life could be lost but not in another; an oil spill could occur in one but not the other, etc. What can be predicted from experience is that for all major events, numerous intangible costs will be incurred.

90. URBANIZATION. Urbanization is presently occurring and will continue to occur throughout the Basin. Development throughout most of the Basin is expected to continue with the absence of mandatory land treatment or design procedures to retard increased stormwater runoff. If development of the Basin continues as predicted without proper control, flood problems will get worse. Urbanization will result in stage increases 2 to 4 feet for most floods in the Basin. These increases may be as great as 7 feet in some locations. Discharges will increase tremedously for frequent flood events (63% for a flood with a 50% chance of occurrence in a given year) and moderately even for rare events (15% for a flood with a 1% chance of occurrence). Plate C-12 shows the effect of urbanization on the discharge frequency curve for the USGS Dutton Mill gage. Average annual flood damages will increase by 67%. A comparison of different flood characteristics as they are today and computed for 2020 are presented in Table C-9.

91. FEDERAL FLOOD CONTROL PROJECT. The Eyre Park project was constructed by the Corps of Engineers and turned over to the City of Chester on 1 June 1954. The project consisted of 3,500 feet of levees and floodwalls 7 to 8 feet high. The project is located on the right bank of the Chester Creek just upstream of 9th Street in the City of Chester. The levees and floodwalls were overtopped during the September 1971 flood. The houses which were protected by this structure have been purchased and demolished, but the YMCA remains in the area.

92. PENNSYLVANIA PROJECTS. Pennsylvania has two projects in the Chester Creek Basin. Pennsylvania has enlarged the pipes and culverts which carry three small Chester Creek tributaries through the Borough of Upland. This project will reduce the flooding which used to be caused in the area by the inadequate drainage system. However, the project will not solve the flooding problems from Chester Creek.

93. Pennsylvania constructed a stream improvement project along Chester Creek in Chester Heights Borough and Aston and Middletown Townships during 1976. This project improved flow conditions under and near the Lenni Road Bridge and reduced minor local flood damages.

94. MUNICIPAL PROJECTS. There are three municipal earthen levee projects located along Chester Creek. All were built as the result of the September 1971 flood. (Reference is made to Plate C-10 for location).
None of these levees are capable of retaining large floods.

TABLE C-9
SELECTED
STAGE/DISCHARGE/DAMAGE DATA
CHESTER CREEK BASIN

| Event | Items 1/ 2/ | Levels of Development 1977 | 2020 3/ |
|---|---|---|---|
| General Initiation of Damage | Stage | 34.2 | 34.3 |
| | Discharge | 4,000 | 4,000 |
| | Damage 4/ | $0 | $0 |
| 25-Year | Stage | 41.8 | 44.1 |
| | Discharge | 11,900 | 15,000 |
| | Damage | 2.6M | 5.0M |
| 50-Year | Stage | 44.8 | 46.8 |
| | Discharge | 16,000 | 19,000 |
| | Damage | 6.5M | 14.0M |
| 100-Year | Stage | 47.7 | 49.8 |
| | Discharge | 20,300 | 23,800 |
| | Damage | 16.2M | 21.5M |
| 250-Year | Stage | 50.2 | 52.2 |
| | Discharge | 28,000 | 32,000 |
| | Damage | 21.8M | 25.2M |
| SPF | Stage | 54.0 | 55.5 |
| | Discharge | 35,800 | 40,900 |
| | Damage | 26.9M | 28.1M |
| | Average Annual Damage 5/ | $720,000 | $1,200,000 |

1/ Stages (MSLD) and discharges (cfs) at the USGS gage at Dutton Mill Road.
2/ Inundation damages at the selected level of flooding in sub-reaches 1A through 18F and 51A through 55 as designated.
3/ Limited growth future. Includes affluence and urbanization.
4/ Damages in millions of dollars (M) at the respective stage of flooding. Damages are in January 1978 dollars.
5/ Non-discounted annual damages in January 1978 dollars.

95. There are two projects built by the City of Chester. The Crozer Park Gardens levee is about 1100 feet long and 5 to 6 feet high. This levee protects a residential area along the right bank between Kerlin Street and the railroad embankment just upstream of Interstate Route 95. The Crozer Park levee is only about 200 feet long and 4 feet high. This levee protects a swimming pool and bath houses in the city park upstream of Kerlin Street.

96. The Toby Farms levee is about 1800 feet long and 3 to 4 feet high. This levee was built by Chester Township to protect a residential area along the left bank of the Creek.

## SUMMARY OF PROBLEMS AND NEEDS

97. During coordination of this study, the most predominant need expressed by Congressional and local interests was for immediate action to solve flood water and flood plain management needs of the Basin. Not only has the Basin been frequently subjected to events of major damage, but it is continuously being plagued by localized stream flooding and stormwater drainage overflow. The frequency of these small localized events is such that the cumulative costs to their victims is considerable. The following sub-paragraphs will present a summary of all these problems and needs.

There is an immediate need for floodwater and flood plain management planning throughout the Chester Creek Basin, but particularly in the lower Basin. The localized high intensity storms come with little warning. These events are extremely dangerous with respect to loss of life.

There are also numerous localized flooding problems directly attributable to poor drainage. The major urban drainage problem remaining in the Basin is the Goose Creek Watershed in the Borough of West Chester and West Goshen Township.

No community in the Basin has a stormwater drainage plan certified by either the United States Department of Housing and Urban Development or the Environmental Protection Agency. Local interests have expressed a need for area wide stormwater planning.

Stormwater drainage systems which presently exist in the Basin completely ignore groundwater recharge problems. There is no provision for recharging the water table.

Lack of unified and readily available computational procedures hinder local communities in establishing and enforcing proper land development. There are regulations requiring no increase in runoff from development, but no procedures to model increased runoff.

## STATUS OF EXISTING AND FUTURE PLANS

98. The Eyre Park section of the City of Chester which was inundated in 1971 flood is being redeveloped. The 216 homes in Eyre Park were purchased by the Chester Redevelopment Authority and the residents have been relocated. The area is presently being developed as athletic fields and parking facilities for the Chester High School. The Chester Redevelopment Authority also has plans for redevelopment of other flood prone areas within the City of Chester. They plan to rehabilitate the Central Business District by creation of a new shopping center between 7th and 9th Streets and construction of new office buildings along the proposed industrial expressway. Land acquisition has begun. However, no new developments are projected to occur in flood plain areas.

99. The Pennsylvania Department of Environmental Resources (DER) in its "State Water Plan", includes the investigation of flooding problems and solutions throughout Pennsylvania. Pennsylvania's study will show the same damage centers as were identified in the Chester Creek Basin Study. Individual damage centers and projects were studied utilizing ongoing studies by the Corps of Engineers, the Soil Conservation Service, and DER to the maximum extent possible. DER has expressed the Commonwealth's desire for complete Corps of Engineers involvement for the Basin and will utilize information developed for this study in their report.

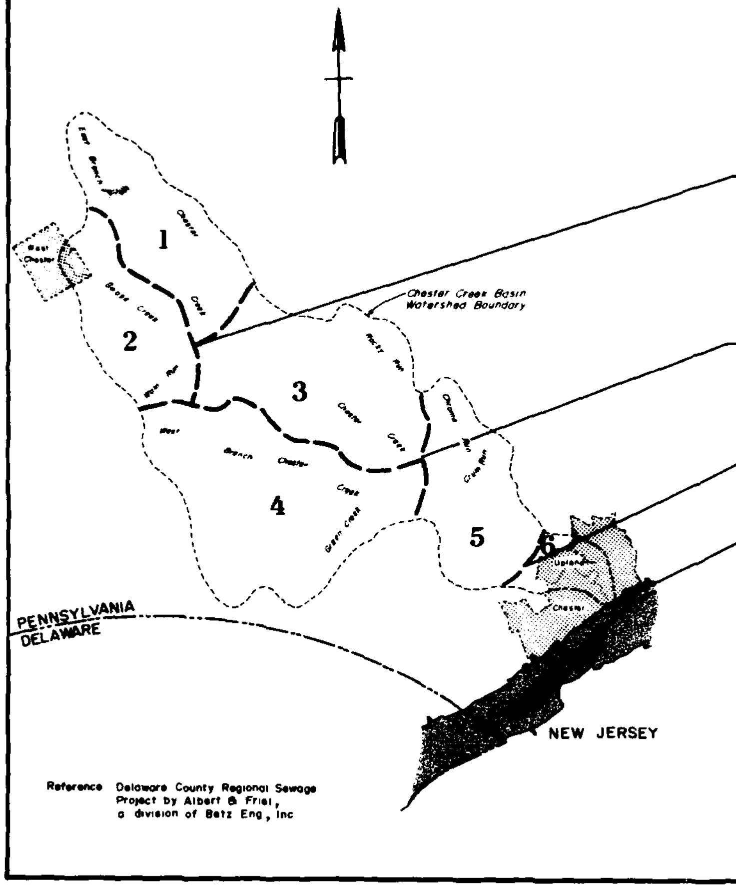
100. The Delaware Valley Regional Planning Commission (DVRPC) is presently conducting a study of southeastern Pennsylvania to include the Chester Creek Basin. A part of this study is entitled the "1973 Drainage and Flood Control Work Program" which developed data requirements for the planning of drainage facilities for the major drainage basins in southeastern Pennsylvania. DVRPC has developed an inventory of stormwater drainage systems in the Delaware Valley and has drafted guidelines. DVRPC efforts are regional in nature and project level studies are not scheduled.

101. There are also other independent studies being conducted by local engineering firms in behalf of local governmental agencies to look at particular problems. One such study was conducted for the Chester School Board for flood protection of the new high school. To date there are no projects scheduled to be financed as a result of any of these studies.

102. Investigations of localized flooding problems at Lenni, in Middletown and Aston Township, West Chester Borough, and West Goshen Township have been completed. To date none of the recommendations have been implemented, nor is there any indication that they ever will be implemented.

## STUDY OBJECTIVES

103. The objective of this study was to develop a floodwater and flood plain management plan for the entire Basin. This objective included the development of a plan for the solution of all existing flooding problems, and the prevention of new ones. All projects and programs included in the plan would need to be justified economically and accepted environmentally and socially. Both structural projects and non-structural programs were considered. Implementation of portions of the plan was to have been carried out by the appropriate Federal and non-Federal institutions. Other information developed during the study but not included in the plan was to have been turned over to local authorities for their use.




ESTIMATED WASTEWATER FLOW (MGD) 1/

| | | 1970 | 1980 | 1985 | 1990 | 2000 | 2020 |
|---|---|---|---|---|---|---|---|
| Sub-Basin | 1 | .632 | 1.583 | 2.288 | 2.812 | 4.153 | 5.252 |
| Sub-Basin | 2 | 1.454 | 1.988 | 2.350 | 2.605 | 3.158 | 3.789 |
| Sub-Total | 1+2 | 2.086 | 3.571 | 4.638 | 5.417 | 7.311 | 9.041 |
| Sub-Basin | 3 | .732 | 1.426 | 1.819 | 2.244 | 3.236 | 5.489 |
| Sub-Basin | 4 | .739 | 3.543 | 5.177 | 6.752 | 9.731 | 14.565 |
| Sub-Total | 1+2+3+4 | 3.557 | 8.540 | 11.634 | 14.413 | 20.278 | 29.095 |
| Sub-Basin | 5 | 1.513 | 2.655 | 3.476 | 3.908 | 4.724 | 6.382 |
| Sub-Total | 1+2+3+4+5 | 5.070 | 11.195 | 15.110 | 18.321 | 25.002 | 35.477 |
| Sub-Basin | 6 | 1.290 | 1.925 | 2.209 | 2.495 | 2.959 | 3.873 |
| Total | 1+2+3+4+5+6 | 6.360 | 13.120 | 17.319 | 20.816 | 27.961 | 39.350 |

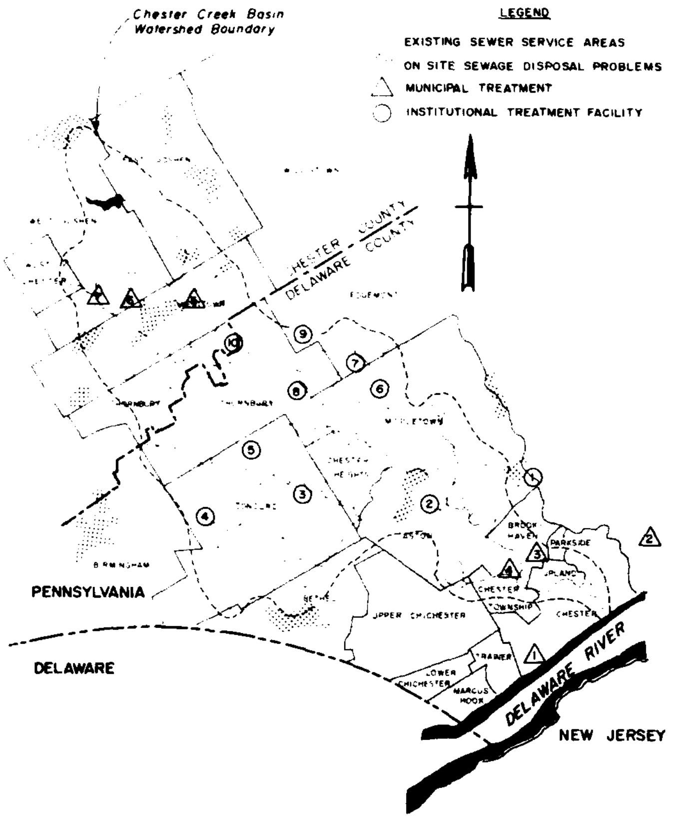
1/ MGD indicates million gallons per day

CHESTER CREEK BASIN, PENNSYLVANIA

# ESTIMATED WASTEWATER FLOW

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE C-1




**MAJOR WASTEWATER POINT SOURCES**

| FACILITY | CONSTRUCTION DATE (YEAR) | TYPE TREATMENT 1 | DESIGN CAPACITY FLOW 2 | RECEIVING STREAM |
|---|---|---|---|---|
| MUNICIPAL FACILITIES △ | | | | |
| 1 Chester City 3 | 1940 | P | 10 01 | Delaware River |
| 2 Eddystone 3 | 1931 | P | 1 0 | Delaware River |
| 3 Brookhaven Borough | 1935 | S | 0 2 | Chester Creek |
| 4 Southwest Delaware Co Authority (Aston Twp) | 1959 | S | 2 0 | Baldwin Run |
| 5 Westtown Twp | 1966 | S | 0 1 | East Chester Creek |
| 6 West Goshen Twp | 1962 | S | 4 0 | Goose Creek |
| 7 West Chester Borough | 1911 1950 | S | 2 0 | Goose Creek |
| INSTITUTIONAL FACILITIES ○ | | | | |
| 1 Old Farm Community Ser | NM | S | 0 01 | Chester Creek |
| 2 Our Lady of Angels College | 1956 | S | 0 05 | Chester Creek |
| 3 Garnet Valley School | 1963 | S | 0 03 | Green Creek |
| 4 Concord Country Club | 1965 | S | 0 013 | West Branch Chester Creek |
| 5 Fox Valley | 1966 | S | 0 06 | West Branch Chester Creek |
| 6 Fair Acres Farm | 1950 | T | 0 10 | Rocky Run |
| 7 Sleighton Farms School | 1957 | T | 0 08 | Rocky Run |
| 8 Delaware County Prison | 1930 | T | 0.08 | West Branch Chester Creek |
| 9 Glen Mills School | 1942 | T | 0 10 | Chester Creek |
| 10 Cheyney State College | 1962 | S | 0.15 | Chester Creek |

1/ Types of treatment are as follows: P - indicates primary
S - indicates secondary, and T - indicates tertiary

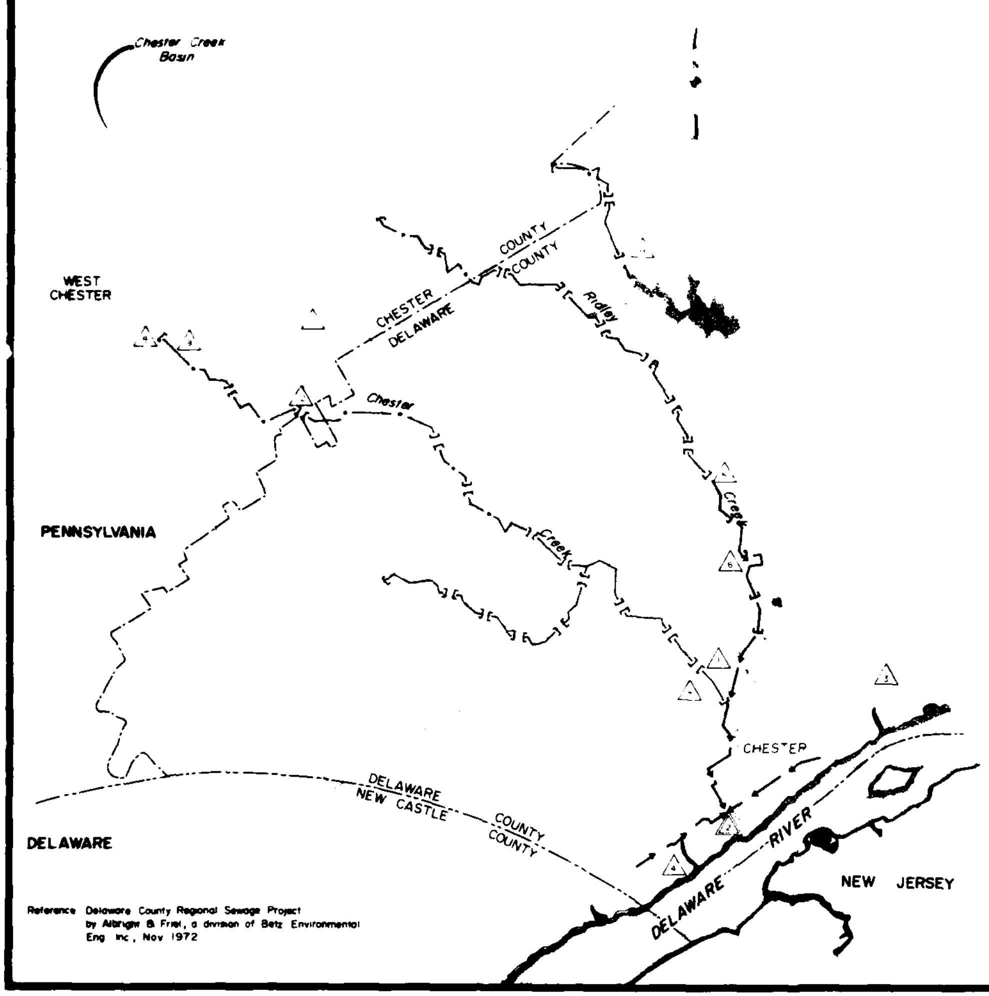
2/ Flow is in million gallons per day

3/ Services population or industries in the Chester Creek Basin

Reference Delaware County Regional Sewage Project by Albright & Friel, a division of Betz Environmental Eng. Inc.

**CHESTER CREEK BASIN, PENNSYLVANIA**
**WASTEWATER MANAGEMENT FACILITIES & PROBLEMS**
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE C-2




Reference Delaware County Regional Sewage Project by Albright & Friel, a division of Betz Environmental Eng Inc., Nov 1972

| | MUNICIPAL WASTEWATER TREATMENT FACILITIES | | | RECOMMENDED SECONDARY TREATMENT CAPACITY MGD | | | |
|---|---|---|---|---|---|---|---|
| NO | NAME | EXISTING CAPACITY MGD | TYPE | 1972 TO 1976 | 1977 TO 1989 | 1990 TO 1999 | 2000 TO 2020 |
| 1 | BROOKHAVEN | 0.2 | TF | x | - | | - |
| 2 | CHESTER CITY | 10.0 | P | 60 | 60 (1) | 90 | 115 (2) |
| 3 | EDDYSTONE | 1.0 | P | x | | | - |
| 4 | MARCUS HOOK | 1.4 | P | x | | | |
| 5 | MEDIA | 1.8 | TF | 1.8 | 1.8 | x | - |
| 6 | ROSE VALLEY | 0.1 | TF | x | | - | - |
| 7 | SOUTHWEST AUTH | 2.0 | TF | 4.0 | 4.0 | x | - |
| 8 | WEST CHESTER | 2.0 | TF | 2.0 | 2.0 | x | |
| 9 | WEST GOSHEN | 2.0 | TF | 4.0 | 4.0 | x | - |
| 10 | WESTTOWN SEWER CO | 0.1 | EA | x | - | - | - |
| 11 | NEWTOWN | 0.0 | AS | 0.25 (1) | x | - | |
| 12 | WESTTOWN SEWER CO. | 0.0 | AS | 1.0 | 1.0 | x | - |

TF TRICKLING FILTER P PRIMARY S SECONDARY EA EXTENDED AERATION AS ACTIVATED SLUDGE
x PHASE OUT FACILITY
1 TEMPORARY TREATMENT FACILITY
2 ADDITION OF TERTIARY TREATMENT UNITS

LEGEND

WASTEWATER TREATMENT FACILITY

REGIONAL WASTEWATER TREATMENT FACILITY

INTERCEPTOR FORCE MAIN 1972 - 1976

INTERCEPTOR FORCE MAIN 1977 - 1999

TRUNK LINE 1972 - 1976

TRUNK LINE 1977 - 1989

TRUNK LINE 1990 - 1999

TRUNK LINE 2000 - 2020

CHESTER CREEK BASIN
PENNSYLVANIA

DELAWARE COUNTY
REGIONAL SEWAGE PROJECT

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE C-3

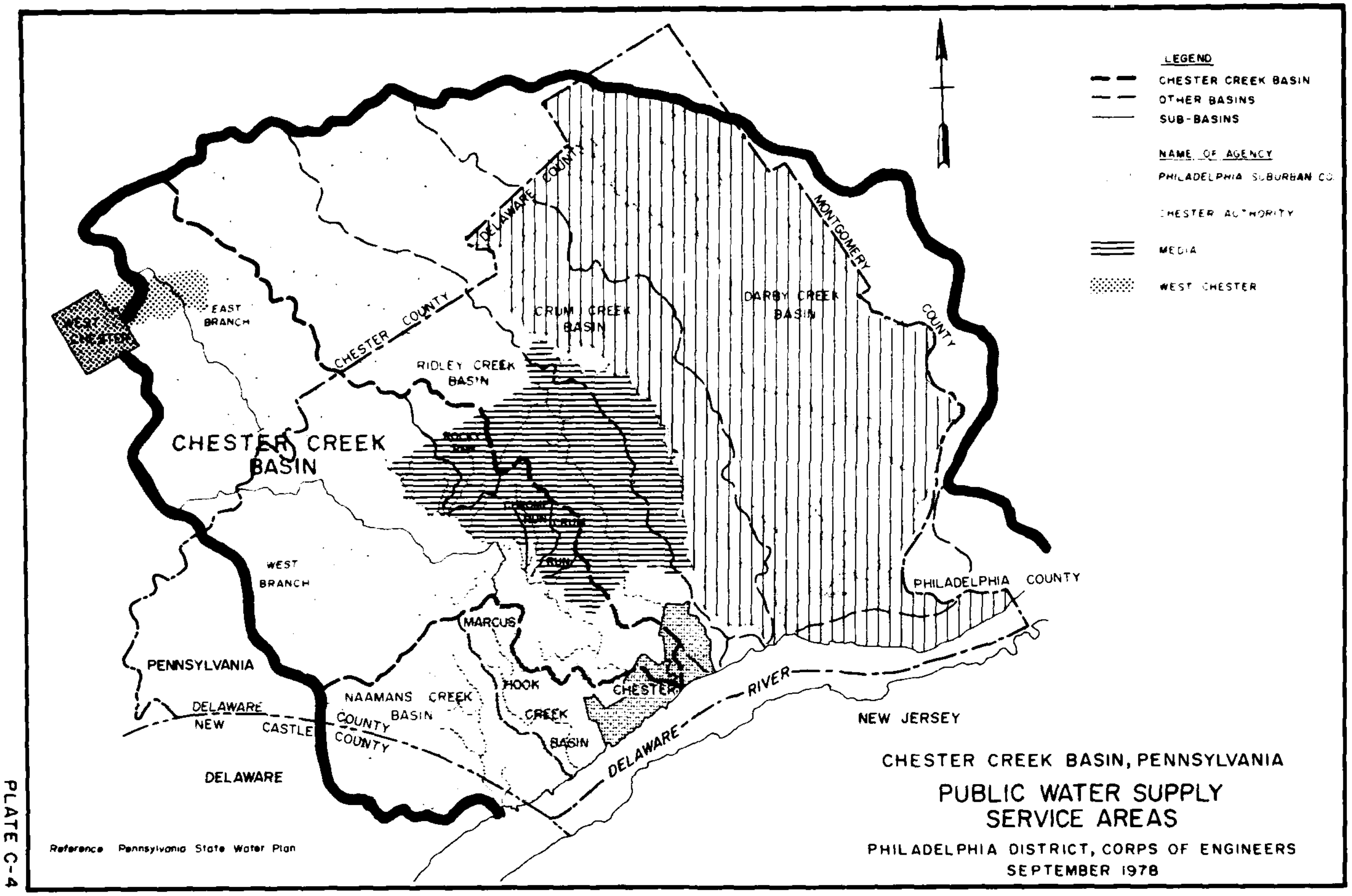

LEGEND
CHESTER CREEK BASIN
OTHER BASINS
SUB-BASINS
NAME OF AGENCY
PHILADELPHIA SUBURBAN CO.
CHESTER AUTHORITY
MEDIA
WEST CHESTER
WEST CHESTER
EAST BRANCH
CHESTER COUNTY
DELAWARE COUNTY
MONTGOMERY COUNTY
CRUM CREEK BASIN
DARBY CREEK BASIN
RIDLEY CREEK BASIN
CHESTER CREEK BASIN
WEST BRANCH
PHILADELPHIA COUNTY
MARCUS
HOOK CREEK BASIN
CHESTER
PENNSYLVANIA
DELAWARE COUNTY
NEW CASTLE COUNTY
NAAMANS CREEK BASIN
DELAWARE
DELAWARE RIVER
NEW JERSEY
CHESTER CREEK BASIN, PENNSYLVANIA
PUBLIC WATER SUPPLY
SERVICE AREAS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978
Reference Pennsylvania State Water Plan

PLATE C-4

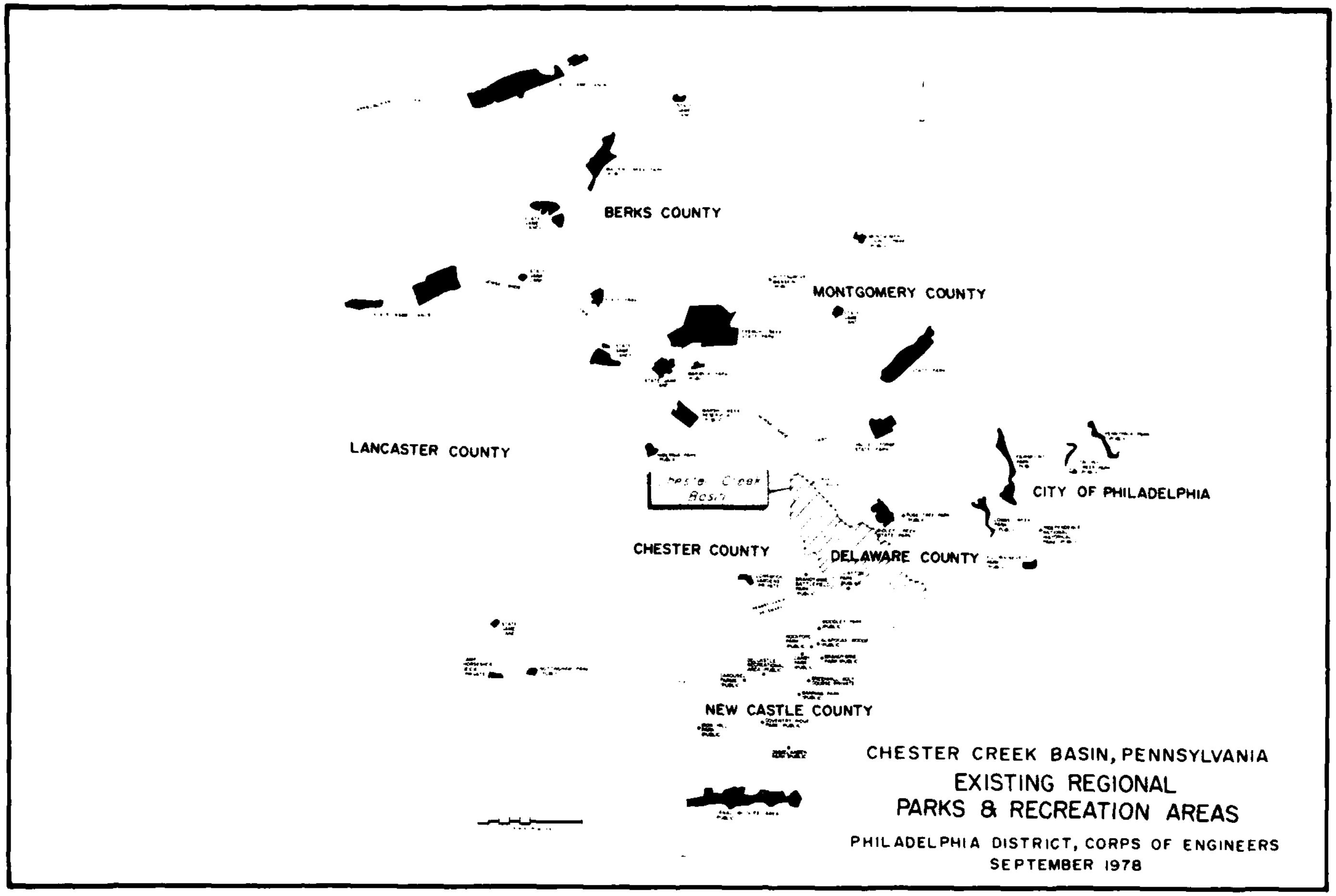
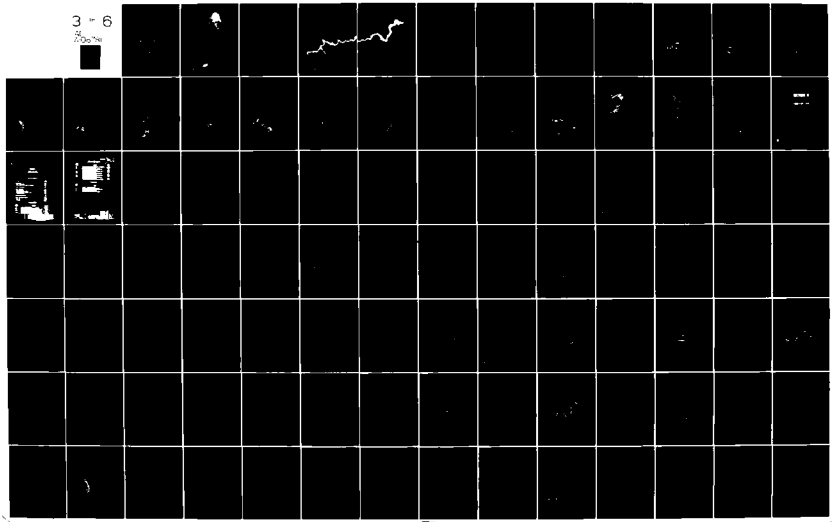
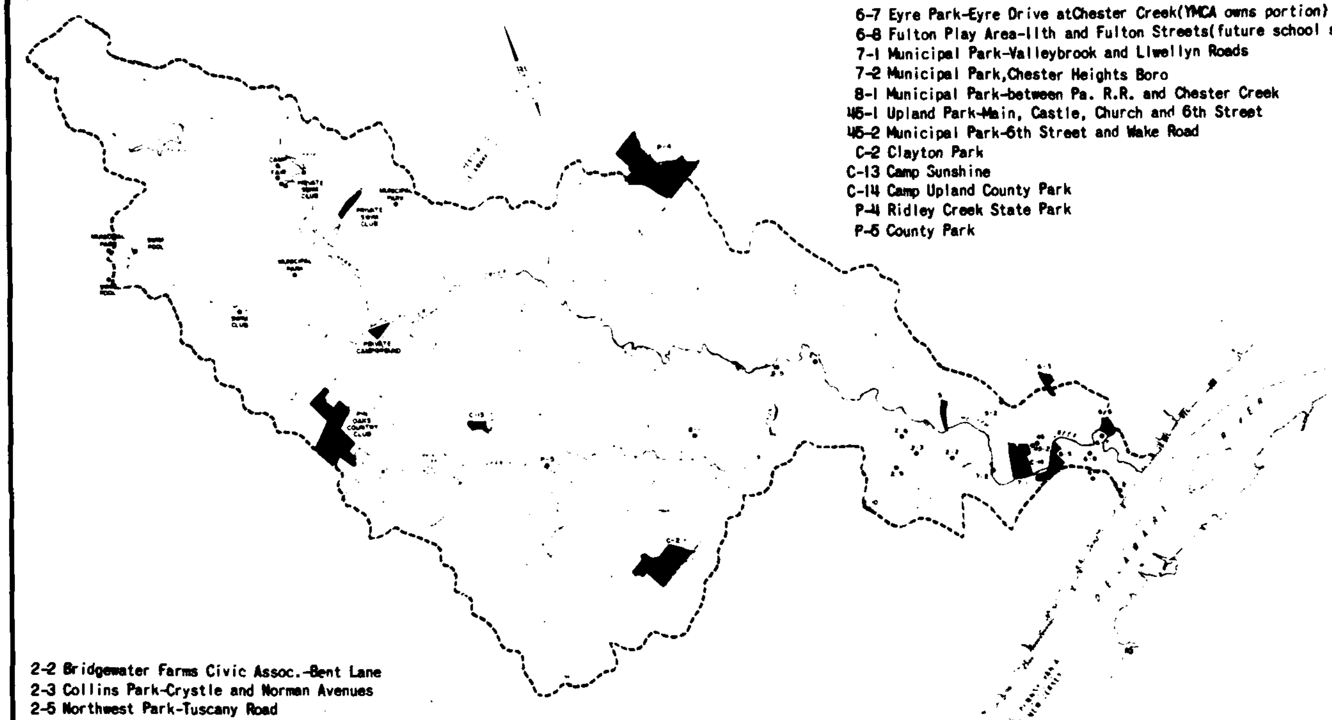

BERKS COUNTY
MONTGOMERY COUNTY
LANCASTER COUNTY
Cheste Creek Basin
CITY OF PHILADELPHIA
CHESTER COUNTY
DELAWARE COUNTY
NEW CASTLE COUNTY
CHESTER CREEK BASIN, PENNSYLVANIA
EXISTING REGIONAL
PARKS & RECREATION AREAS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE C 5

AD-A106 781 ARMY ENGINEER DISTRICT PHILADELPHIA PA F/G 13/2
WATER RESOURCES STUDY FOR METROPOLITAN CHESTER CREEK BASIN, PEN--ETC(U)
SEP 78
UNCLASSIFIED DAEN/NAP-12000/WRS-78/09 NL





6-7 Eyre Park-Eyre Drive atChester Creek(YMCA owns portion)
6-8 Fulton Play Area-11th and Fulton Streets(future school site)
7-1 Municipal Park-Valleybrook and Llwellyn Roads
7-2 Municipal Park,Chester Heights Boro
8-1 Municipal Park-between Pa. R.R. and Chester Creek
U5-1 Upland Park-Main, Castle, Church and 6th Street
U5-2 Municipal Park-6th Street and Wake Road
C-2 Clayton Park
C-13 Camp Sunshine
C-14 Camp Upland County Park
P-4 Ridley Creek State Park
P-5 County Park

2-2 Bridgewater Farms Civic Assoc.-Bent Lane
2-3 Collins Park-Crystle and Norman Avenues
2-5 Northwest Park-Tuscany Road
2-6 Eagle Field-Mount and Convent Roads, Rockdale
2-9 Valley View Civic Assoc.-South of Raymond, East of Stella Lane
2-10 Woodbrook Civic Assoc.-Lampost Lane
2-11 Sun Roc Little League Ballfield-Pennell Road
5-1 Creek Road Park-both sides of Creek Road at Chester Creek
5-2 Sampson Field-Nathan Avenue
6-2 Chester Boys Club-Front and Fulton Streets
6-3 Chester Park at Ridley Creek
6-5 Crozer Park-Finland Drive at Chester Creek
6-6 Deshong Park-11th Street and Edgmont Avenue

CHESTER CREEK BASIN, PENNSYLVANIA
EXISTING BASIN
PARKS & RECREATION AREAS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE C-6

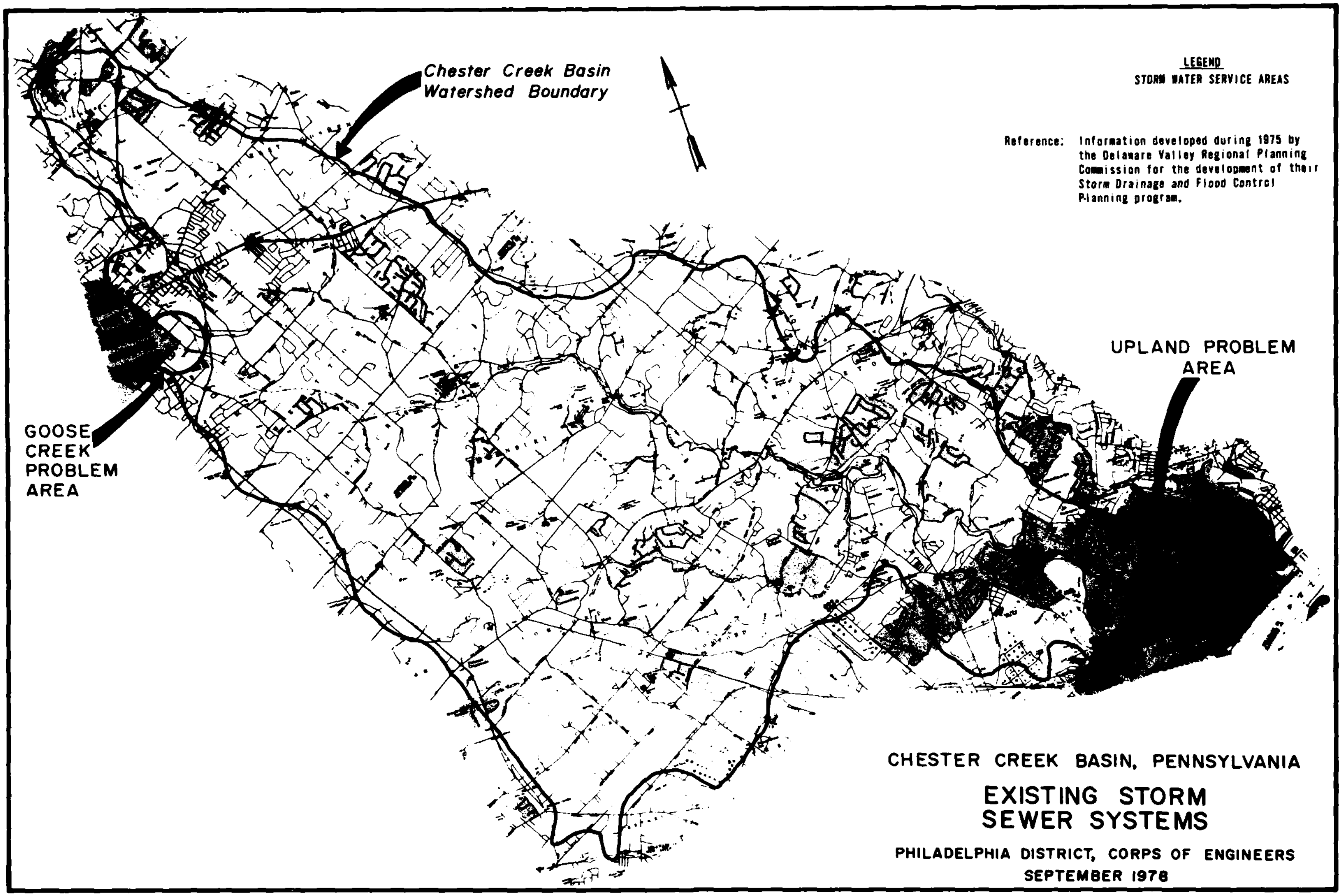
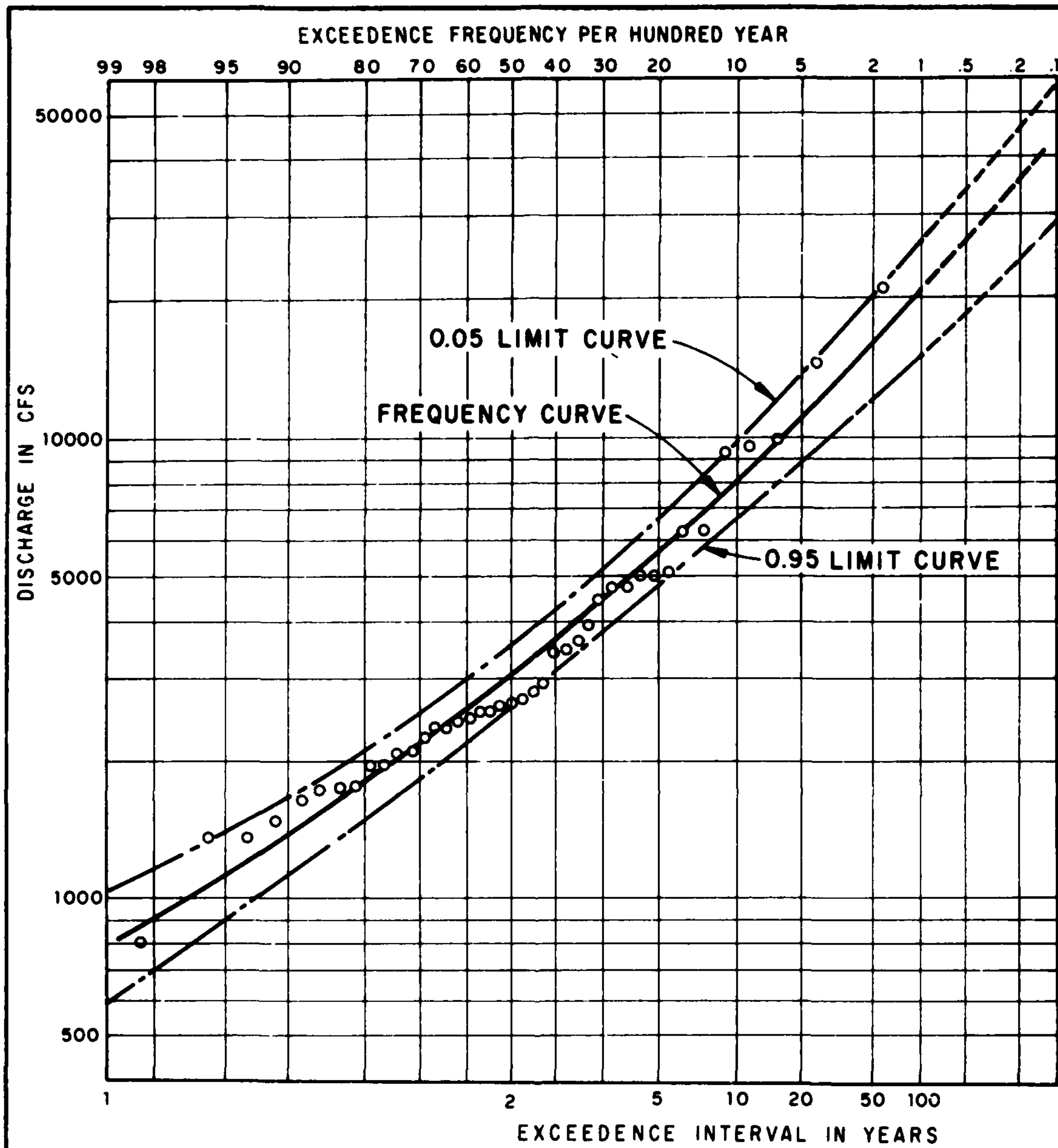

Chester Creek Basin Watershed Boundary
LEGEND
STORM WATER SERVICE AREAS
Reference: Information developed during 1975 by the Delaware Valley Regional Planning Commission for the development of their Storm Drainage and Flood Control Planning program.
UPLAND PROBLEM AREA
GOOSE CREEK PROBLEM AREA
CHESTER CREEK BASIN, PENNSYLVANIA
EXISTING STORM SEWER SYSTEMS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE C-7




NOTE: Discharge-frequency relationship at the U.S.G.S. Gage at Dutton Mill Road.

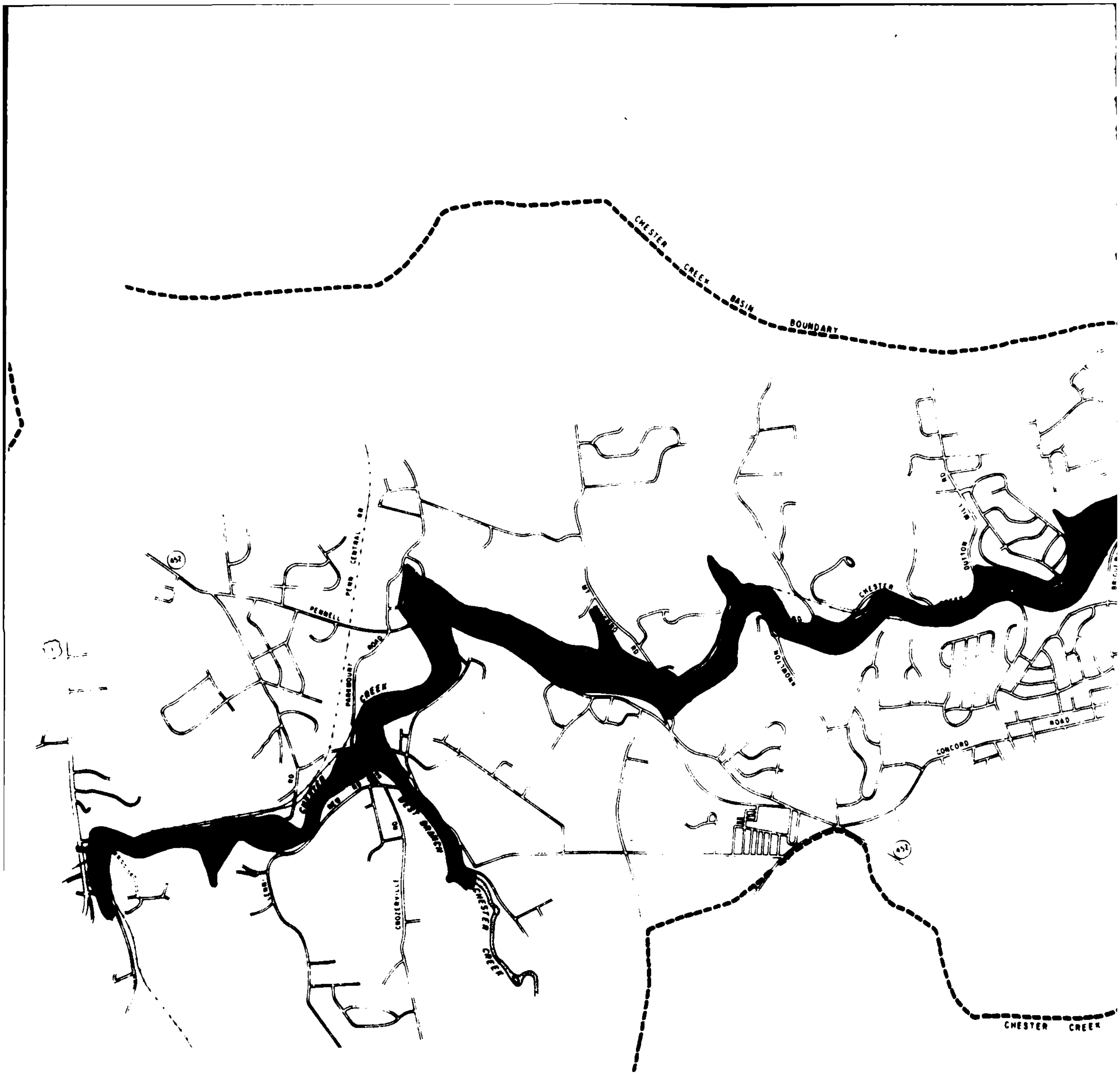
CHESTER CREEK BASIN, PENNSYLVANIA

DISCHARGE - FREQUENCY

U.S.G.S. GAGE

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978



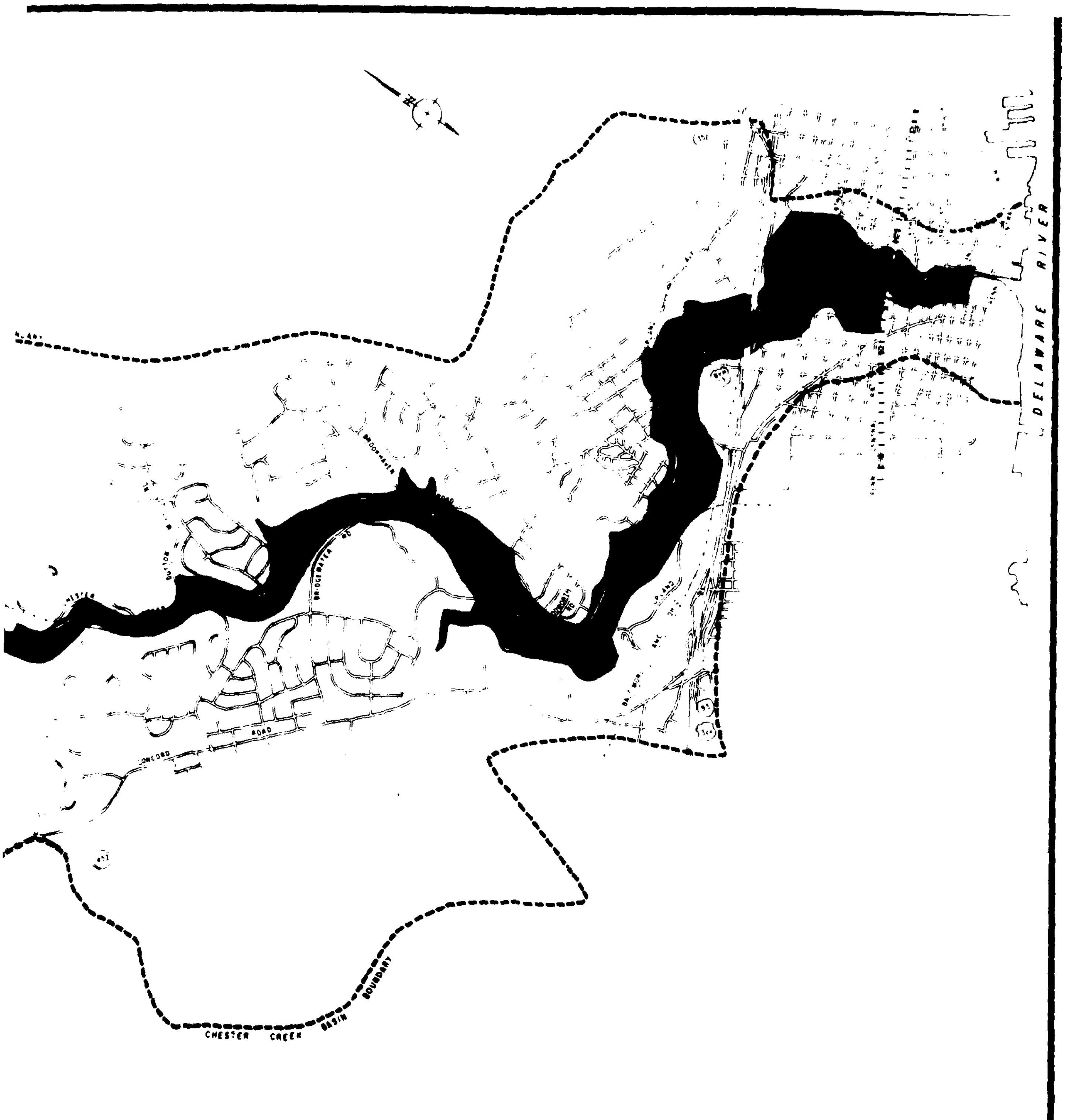

LEGEND

STANDARD PROJECT FLOOD

100-YEAR FLOOD

0 1000 2000 3000 4000 5000

SCALE OF FEET



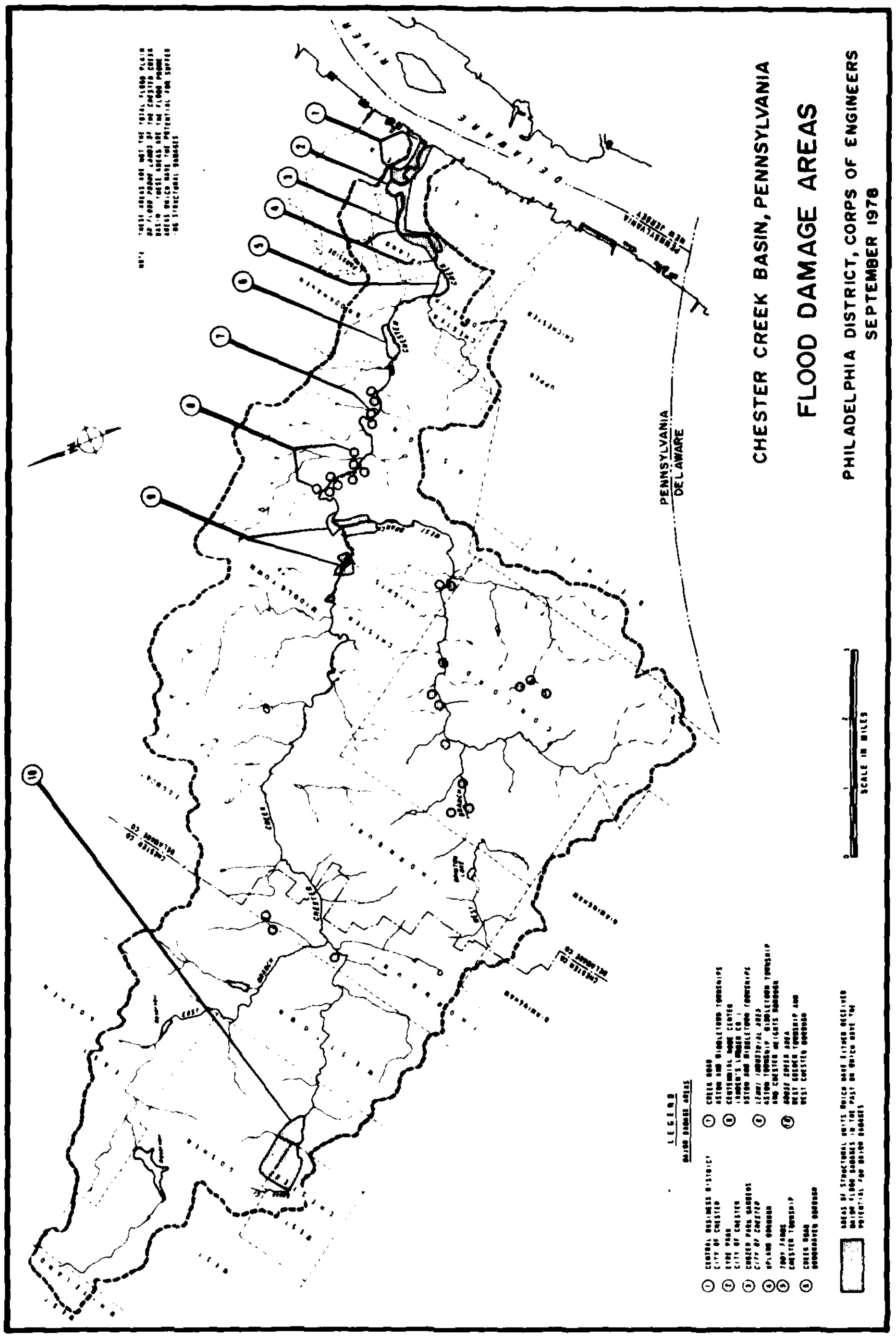

CHESTER CREEK BASIN, PENNSYLVANIA

**FLOOD PLAIN LIMITS**
**SELECTED FLOODS**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

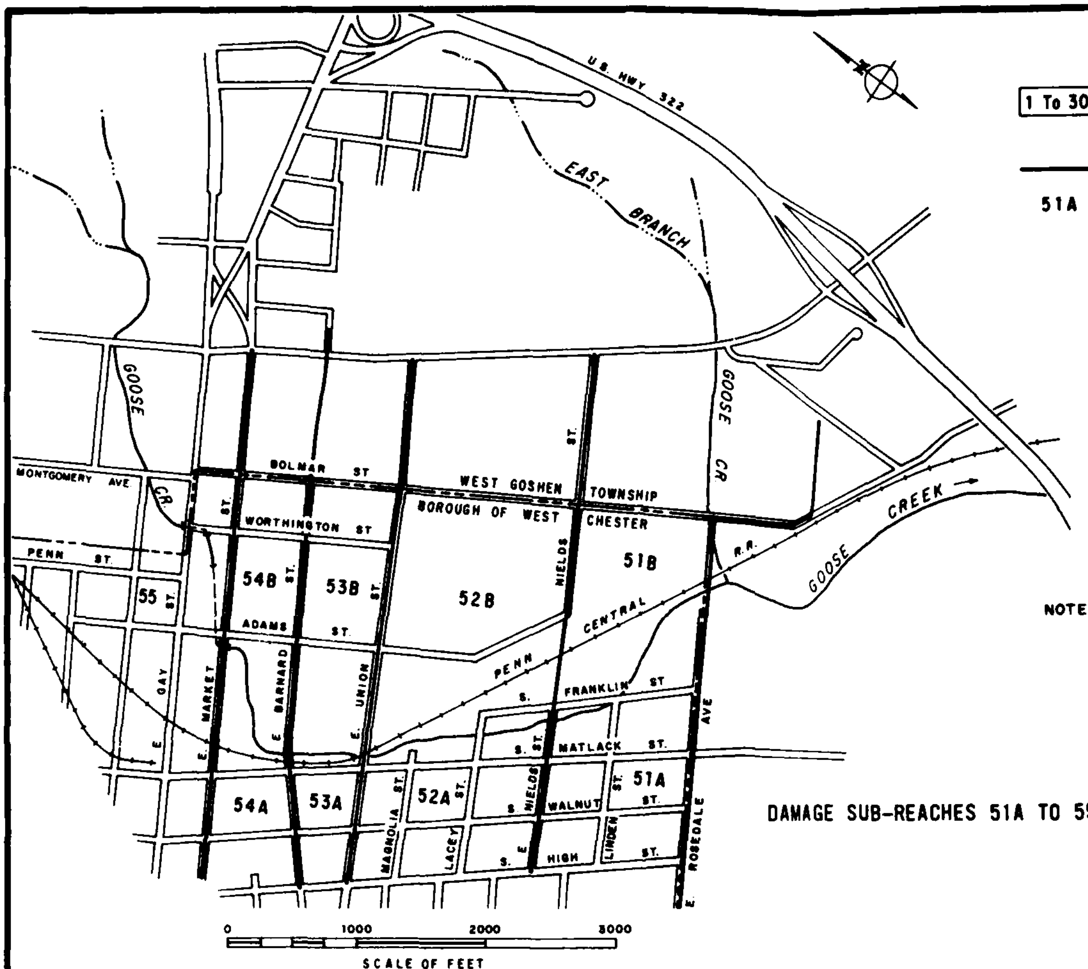
**SEPTEMBER 1978**

2



CHESTER CREEK BASIN, PENNSYLVANIA
FLOOD DAMAGE AREAS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978
PENNSYLVANIA
DELAWARE
LEGEND
SCALE IN MILES


PLATE C-10

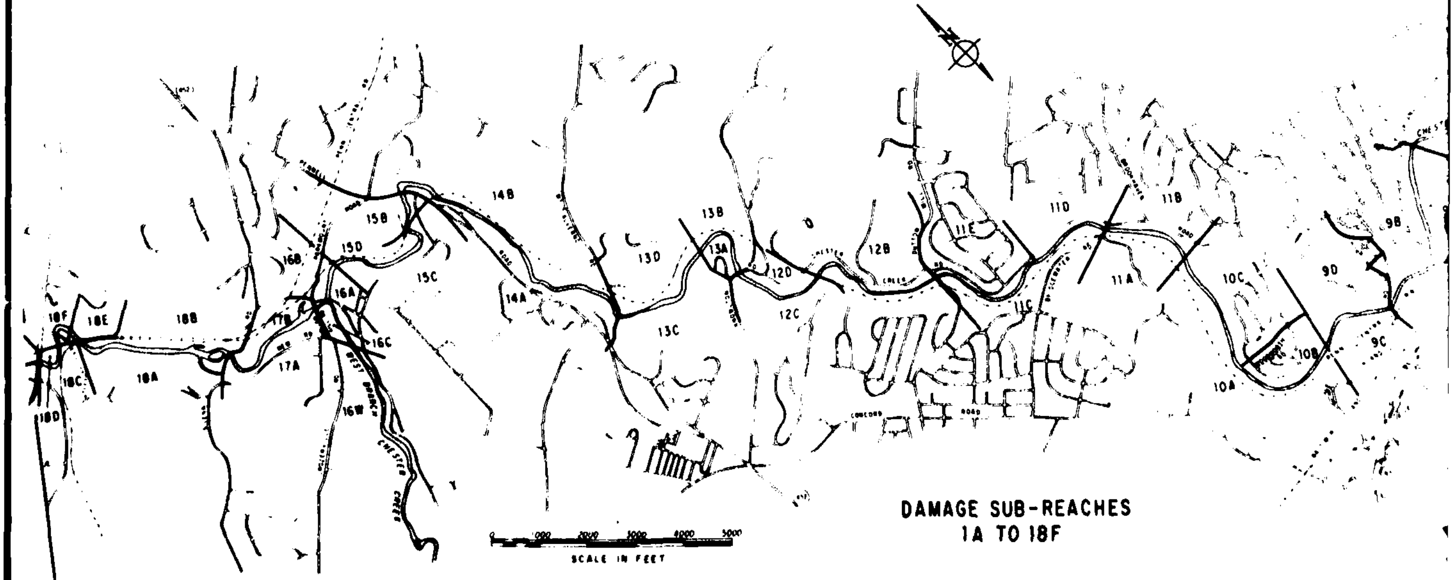



## LEGEND

| | |
|---|---|
| 1 To 30 | ALLOCATION OF NUMBERS OF REACHES THROUGHOUT THE CHESTER CREEK BASIN (All the numbers allocated were not necessarily required) |
| ——— | SUB-REACH LIMIT |
| 51A | SUB-REACH DESIGNATION |

NOTE. REACHES 1-18 AND 51-55 CONTAIN THE GREATEST CONCENTRATION OF HISTORIC AND POTENTIAL DAMAGES IN THE CHESTER CREEK BASIN.

DAMAGE SUB-REACHES 51A TO 55



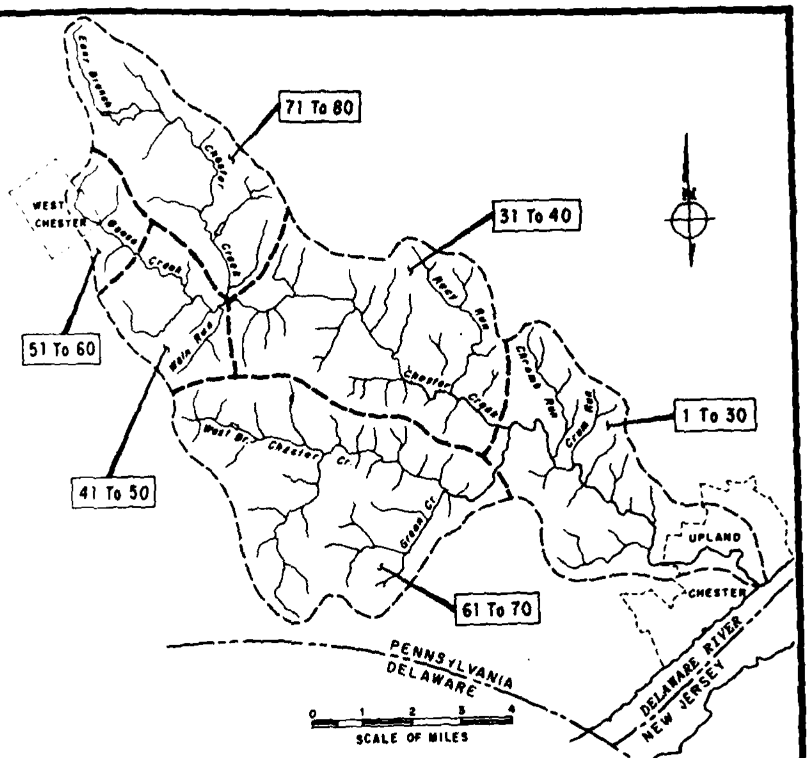

DAMAGE SUB-REACHES
1A TO 18F

PLATE C-11

**LEGEND**

| | |
|---|---|
| 1 To 30 | ALLOCATION OF NUMBERS OF REACHES THROUGHOUT THE CHESTER CREEK BASIN *(All the numbers allocated were not necessarily required)* |
| ——— | SUB-REACH LIMIT |
| 51A | SUB-REACH DESIGNATION |

NOTE. REACHES 1-18 AND 51-55 CONTAIN THE GREATEST CONCENTRATION OF HISTORIC AND POTENTIAL DAMAGES IN THE CHESTER CREEK BASIN.




ALLOCATION OF DAMAGE SUB-REACHES

51A TO 55

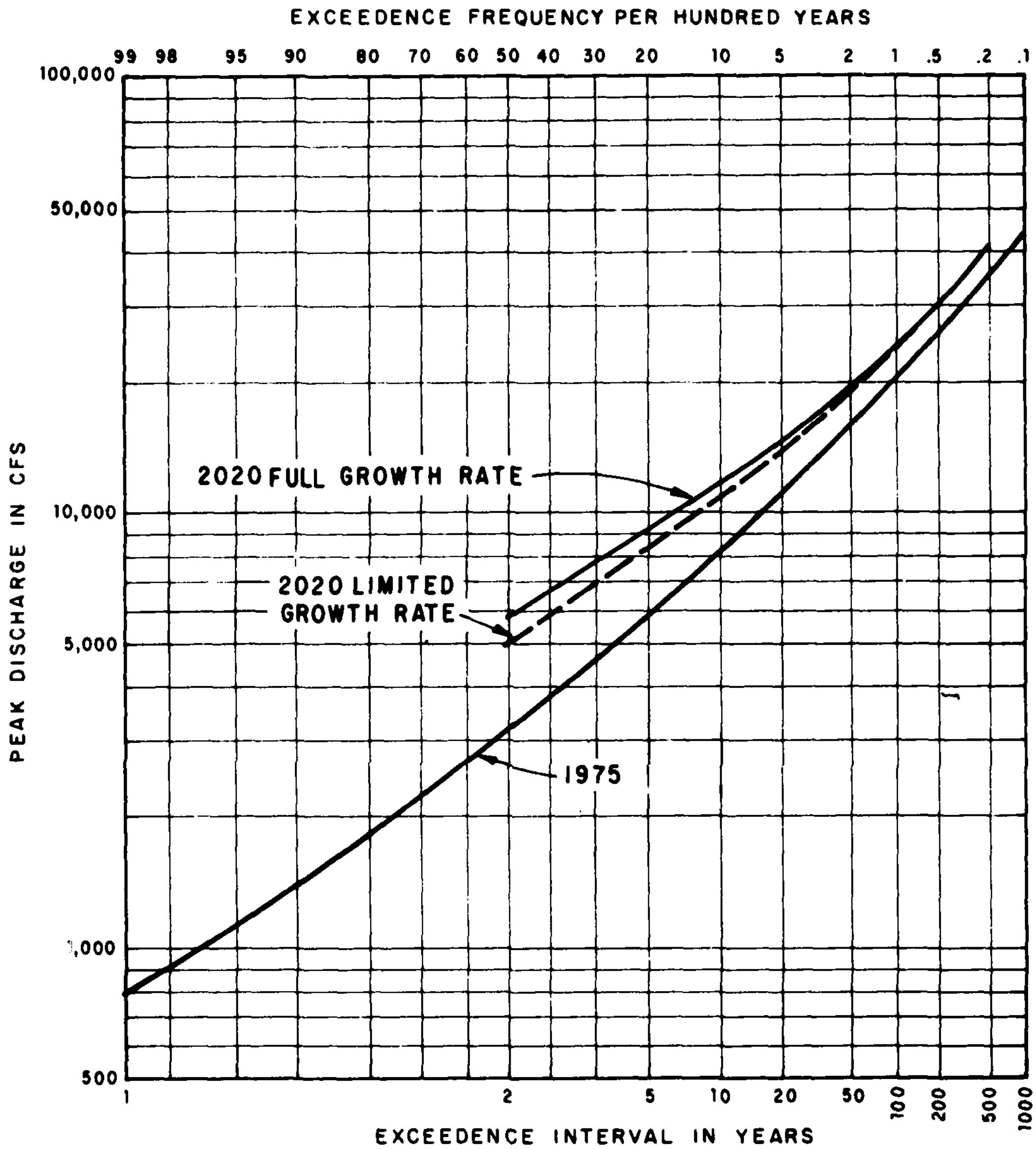
;UB-REACHES
TO 18F

CHESTER CREEK BASIN, PENNSYLVANIA

# FLOOD DAMAGE SUB-REACHES

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978



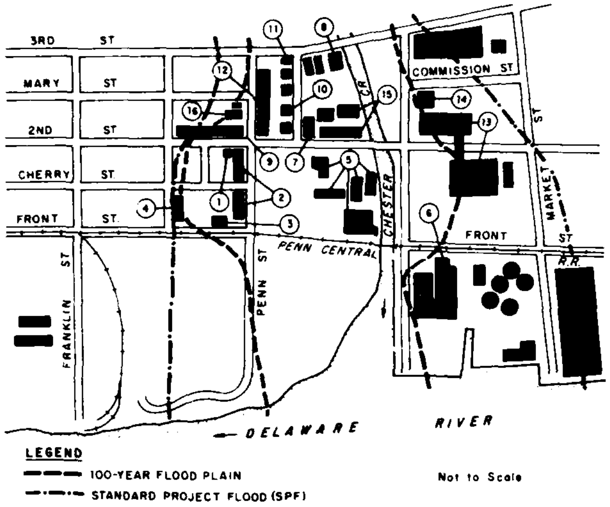

NOTE: For a drainage area (sub-basins 1 through 11) of 61.1 sq. mi. above Dutton Mill Road.

CHESTER CREEK BASIN, PENNSYLVANIA

**EFFECT OF URBANIZATION ON DISCHARGE-FREQUENCY**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978




| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 1A | Community Laundry Service<br>211 W. 2nd Street | Commercial |
| 2 | 1A | Penn Street<br>100-126, 10 homes | Residential |
| 3 | 1A | 208 W. Front<br>1 home | Residential |
| 4 | 1A | Concord<br>103-131, 13 homes | Residential |
| 5 | 1A | Sewage Pump Station<br>West 2nd Street at Creek | Public |
| 6 | 1B | Scott Paper<br>West 2nd E. side of Creek | Industrial |
| 7 | 2A | L & H Auto Body<br>132-34 W. 2nd Street | Commercial |
| (8) | (2A) | (State Liquor Store)<br>119-121 W. 3rd Street | (Commercial) |
| 9 | 2A | Margaret's Beauty Shop<br>200 West 2nd Street | Commercial |
| (10) | (2A) | (AA West Roofers)<br>Dock Street | (Commercial) |
| (11) | (2A) | (Burger's Plumbing Supply)<br>Warehouse 3rd Street | (Commercial) |
| (12) | (2A) | (Penn Street)<br>215-17, 2 homes | (Residential) |
| 13 | 2B | Medford Meats<br>18 W. 2nd Street | Industrial |
| 14 | 2B | Holt & Crawford<br>Wholesale Grocercy | Commercial |
| 15 | 2A | Chester Vocational<br>High School Annex<br>126 W. 2nd Street | Public |
| 16 | 2A | Church<br>210-12 Penn Street | Public |
| 17 | 2B | Murray's Bar<br>41 3rd Street | Commercial |
| 17 | 2B | Furniture Outlet<br>37-39 3rd Street | Commercial |
| 17 | 2B | Ben Franklin Electric Supply<br>29-33 3rd Street | Commercial |

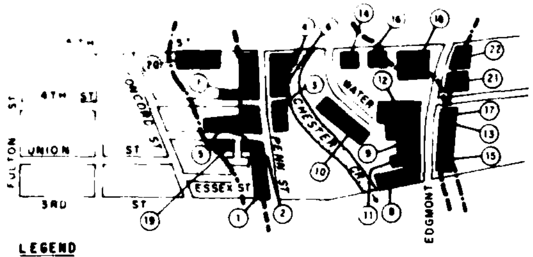
**NOTES**

1. Inventory based on September 1974 damage survey with January 1976 and October 1977 supplemental surveys.
2. Buildings abandoned and removed prior to January 1978 are not included. Buildings abandoned after January 1976 are noted with brackets.

## CHESTER CREEK BASIN, PENNSYLVANIA
## FLOOD PRONE UNITS
## DAMAGE SUB-REACHES 1A, 1B, 2A & 2B

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE C-13




**LEGEND**

100-YEAR FLOOD PLAIN

STANDARD PROJECT FLOOD (SPF)

| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 3A | Baylin Hardware 200 E. 3rd Street | Commercial |
| 2 | 3A | Penn Street 300 and 400 Block, 16 homes | Residential |
| 3 | 3A | *Chester Supply Co.* 401 Penn Street | Commercial |
| 4 | 3A | State Health Center 151 W. 5th Street | Commercial/Public |
| (5) | (3A) | (West 4th Street) 200 Block, 12 homes | (Residential) |
| 6 | 3A | Crozier-Chester Medical Center 151 W. 5th Street | Commercial/Public |
| 7 | 3A | Minor Street 200 Block, 4 homes | Residential |
| 8 | 3B | Izzy's Loan Officer 110-116 W. 3rd Street | Commercial |
| 9 | 3B | Delaware County Tobacco Co., Inc., 312 Edgmont | Commercial |
| 10 | 3B | Sandrose Trophy 5th and Water Streets | Industrial |
| 11 | 3B | Berger's Plumbing & Heating Supply 306 Edgmont | Commercial |
| 12 | 3B | Hardware & Supply Co. of Chester 4th and Edgmont | Commercial |
| (13) | (3B) | (Harry's Shoe) 315-317 Edgmont | (Commercial) |
| 14 | 3B | Vocational School for Practical Nursing 147 W. 5th Street | Commercial/Public |
| (15) | (3B) | (Morton Furniture) 104-108 W. 3rd Street | (Commercial) |
| 16 | 3B | V. J. Pace & Sons 131-133 W. 5th Street | Commercial |
| (17) | (3B) | (Crystal Bar) 37 W. 4th Street | (Commercial) |
| 18 | 3B | U.S. Post Office Edgmont and 5th Streets | Public |
| 19 | 3A | West 4th Street 200 Block, 5 homes | Residential |
| 20 | 3A | West 5th Street 200 Block, 2 homes | Residential |
| (21) | (3B) | (Reddington Electric) 400 *Edgmont* | (Commercial) |
| (21) | (3B) | (Apartments) 400 Block, Edgmont | (Commercial) |
| (22) | (3B) | (Law Offices) 419 Edgmont | (Commercial) |
| 22 | 3B | Sandy Signs 423 Edgmont | Commercial |
| 22 | 3B | E&L Painting and Wallpaper Center 425 Edgmont | Commercial |

**NOTES**

1. Inventory based on September 1974 damage survey with January 1976 and October 1977 supplemental surveys.
2. Buildings abandoned and removed prior to January 1976 are not included. Buildings abandoned after January 1976 are noted with brackets.

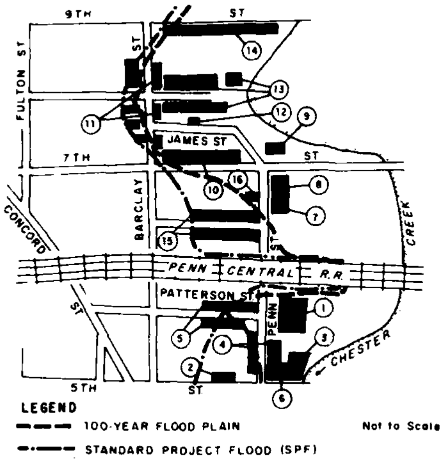
CHESTER CREEK BASIN, PENNSYLVANIA

FLOOD PRONE UNITS

DAMAGE SUB-REACHES 3A & 3B

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978



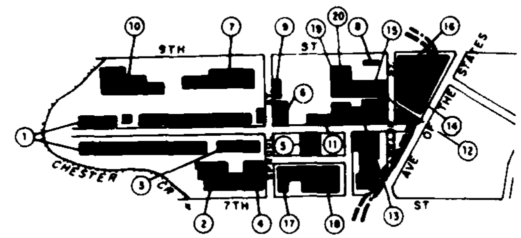

| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 15 | 4D | Woodrow Street<br>200 Block, 9 homes | Residential |
| 16 | 4D | 614 Penn Street<br>1 home | Residential |

| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 4A | Penn St. Day Care Center<br>-31 Penn Street | Commercial/Public |
| 2 | 4A | West 5th Street<br>200 Block, 7 homes | Residential |
| 3 | 4A | PA. Bureau of Employment<br>150 W. 5th Street | Commercial/Public |
| 3 | 4A | Community Nursing Service<br>150 W. 5th Street | Commercial/Public |
| 4 | 4A | Penn Street<br>500 Block, 14 homes | Residential |
| 5 | 4A | Patterson Street<br>200 Block, 19 homes | Residential |
| 6 | 4A | Empty Office, 160 W. 5th St. | Commercial |
| 6 | 4A | Community Advisory Center<br>5th and Penn Streets | Commercial |
| (7) | (4D) | (C&D Bar, 631 Penn Street) | (Commercial) |
| (8) | (4D) | (Lee & Goodbyes Bar/Restaurant)<br>135 W. 7th Street | (Commercial) |
| 9 | 5A | Lee Tire<br>136 W. 7th Street | Commercial |
| 10 | 5A | West 7th Street<br>200 Block, 16 homes | Residential |
| 11 | 5A | Barclay Street<br>700 and 800 Block, 12 homes | Residential |
| 12 | 5A | James Street<br>200 Block, 2 homes | Residential |
| 13 | 5A | West 8th Street<br>200 Block, 13 homes | Residential |
| 14 | 5A | West 9th Street<br>200 Block, 19 homes | Residential |

**NOTES**

1. Inventory based on September 1974 damage survey with January 1976 and October 1977 supplemental surveys.
2. Buildings abandoned and removed prior to January 1976 are not included. Buildings abandoned after January 1976 are noted with brackets.

**CHESTER CREEK BASIN, PENNSYLVANIA**
**FLOOD PRONE UNITS**
**DAMAGE SUB-REACHES 4A, 4D & 5A**
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978




| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 5B | West 8th Street<br>Unit Block, 69 homes | Residential |
| 2 | 5B | L&H Manufacturer<br>10 W. 7th Street | Industrial |
| 3 | 5B | National Guard Armory<br>712 Sproul Street | Commercial |
| 4 | 5B | Man's World<br>16 W. 7th Street | Commercial |
| 4 | 5B | Lou's Shoe Bazaar<br>14 W. 7th Street | Commercial |
| 5 | 5B | John Spencer Inc.<br>8th near Sproul | Commercial |
| 6 | 5B | Delaware County Retardation<br>Board, 809 Sproul Street | Commercial/Public |
| 7 | 5B | L&H Manufacturing<br>9th and Sproul Streets | Industrial |
| 8 | 5B | Gas Station Lot<br>9th and Welsh Streets | Commercial |
| 9 | 5B | Motor Car Supply<br>805 Sproul Street | Commercial |
| 10 | 5B | King Chevrolet<br>75 W. 9th Street | Commercial |
| 11 | 5B | Delaware County Times<br>8th Street near Sproul | Commercial |
| (12) | (5B) | (Office Space, 818 Welsh Street) | (Commercial |
| (12) | (5B) | (East End Lounge Bar)<br>802 Welsh Street | (Commercial |
| 13 | 5B | Boyd Art Theater<br>8th and Welsh Streets | Commercial |
| (14) | (5B) | (Pontillo's Apartments)<br>807 Welsh Street | (Commercial |
| (14) | (5B) | (Babyland)<br>800 Avenue of the States | (Commercial |
| 15 | 5B | Iron Workers Savings and Loan<br>814 Welsh Street | Commercial |
| 15 | 5B | Dr. M. M. Peller, Chester Optical<br>804 Welsh Street | Commercial |
| 15 | 5B | Foot Doctor's Office<br>806 Welsh Street | Commercial |
| 16 | 5B | Chester Masonic Association<br>9th and Welsh Streets | Commercial |
| 17 | 5B | YWCA<br>12 W. 7th Street | Public |
| 18 | 5B | Office Space<br>2, 4, and 6 W. 7th Street | Commercial |
| 19 | 5B | Downham Press<br>5 East 9th Street | Commercial |
| 20 | 5B | O. Peltzman, CPA<br>5 East 9th Street | Commercial |

**NOTES**

1. Inventory based on September 1974 damage survey with January 1976 and October 1977 supplemental surveys.
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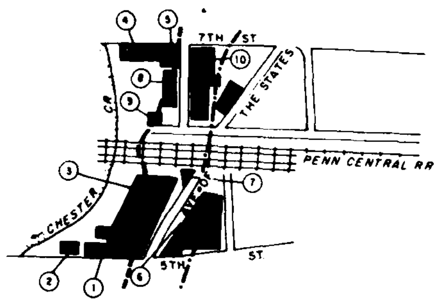
## CHESTER CREEK BASIN, PENNSYLVANIA
## FLOOD PRONE UNITS
## DAMAGE SUB-REACH 5B

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE C-16




**LEGEND**

100-YEAR FLOOD PLAIN

STANDARD PROJECT FLOOD (SPF)

Not to Scale

| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 4B | Augustine Tailor, 126 W. 5th Street | Commercial |
| 1 | 4B | Greyhound Bus Terminal<br>124 W. 5th Street | Commercial |
| 2 | 4B | 76 Gas Station, 130 W. 5th Street | Commercial |
| 3 | 4B | Dr. John A. Minatella, Dentist<br>122 W. 5th Street | Commercial |
| 3 | 4B | Reliable Appliance Company<br>120 W. 5th Street | Commercial |
| 4 | 4C | Lancaster Farmer's Market<br>19 West 7th Street | Commercial |
| 4 | 4C | Swift Cleaners, 13 W. 7th Street | Commercial |
| 4 | 4C | Julie's Princess Hotel-Bar<br>17 W. 17th Street | Commercial |
| 5 | 4C | Delaware County Board of Assistance, 1-7 W. 7th Street | Commercial/Public |
| 6 | 4B | Chester Arms Pharmacy<br>501 Edgmont Street | Commercial |
| 6 | 4B | Palm's TV Service, 505 Edgmont St. | Commercial |
| 6 | 4B | Discount Cleaners, 507 Edgmont St. | Commercial |

| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 6 | 4B | 4 Vacant Shops<br>509, 548, 550, 552 Edgmont Street | Commercial |
| 6 | 4B | Cigarette and News Shop<br>511 Edgmont Street | Commercial |
| 6 | 4B | Modern Stationers and Supply Company<br>513 Edgmont Street | Commercial |
| 6 | 4B | Hadassah Thrift Shop, 515 Edgmont Street | Commercial |
| 7 | 4B | Vacant Building, Edgmont and Sproul Sts. | Commercial |
| 8 | 4C | 612 Sproul Street, 1 home | Residential |
| 8 | 4C | Reade & Advisor, 614 Sproul Street | Commercial |
| 8 | 4C | Lillian Rosati Hair Dresser<br>616 Sproul Street | Commercial |
| 8 | 4C | Hernicks Orthopedic Shoes<br>618 Sproul Street | Commercial |
| 8 | 4C | Chester-Upland School District Vocational School, 620 Sproul Street | Public |
| 8 | 4C | Spitz Coffee Shop, 622 Sproul Street | Commercial |
| 8 | 4C | State Liquor Store, 624 Sproul Street | Commercial |
| 9 | 4C | Chester Housing Authority, 6th Street | Commercial/Public |
| 10 | 4C | Terminal Seafood, 6th & Sproul Streets | Commercial |
| 10 | 4C | Standard Supply, 6th & Sproul Streets | Commercial |
| 10 | 4C | Barber Shop, 615 Sproul Street | Commercial |
| 10 | 4C | Law Offices, 617 Sproul Street | Commercial |
| (10) | (4C) | (2 Vacant Buildings, 600 Block, Sproul St.) | (Residential) |
| (10) | (4C) | (Sproul Street, 600 Block, 7 homes) | (Residential) |

**NOTES**

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2. Buildings abandoned and removed prior to January 1976 are not included. Buildings abandoned after January 1976 are noted with brackets.

CHESTER CREEK BASIN, PENNSYLVANIA

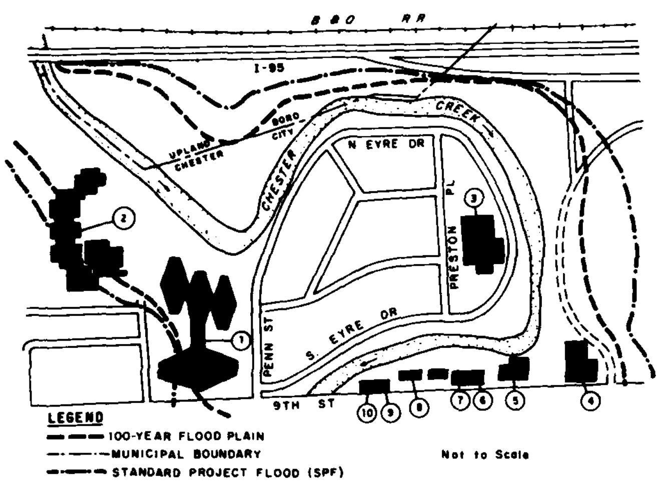
## FLOOD PRONE UNITS

## DAMAGE SUB-REACHES 4B & 4C

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

PLATE C-17




| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 6A | Chester High School<br>9th and Barclay Streets | Public |
| 2 | 6A | Christopher Columbus<br>Elementary School<br>10th and Fulton Streets | Public |
| 3 | 6B | YMCA (Eyre Park)<br>Preston Place | Public |
| 4 | 6C | Pep Boys<br>9th and Welsh Streets | Commercial |
| 5 | 6C | Auto Parts<br>8 E. 9th Street | Commercial |
| 6 | 6C | The Rainbow Diner<br>2-6 W. 9th Street | Commercial |
| 7 | 6C | BPO Elks Club $488<br>10 W. 9th Street | Public |
| 8 | 6C | Wellington's Texaco Station<br>54 W. 9th Street | Commercial |
| 9 | 6C | Hi Z Typewriters<br>58 W. 9th Street | Commercial |
| 10 | 6C | Bridge Cafe<br>60 W. 9th Street | Commercial |

NOTES

1. Inventory based on September 1974 damage survey with January 1976 and October 1977 supplemental surveys.
2. Buildings abandoned and removed prior to January 1976 are not included.

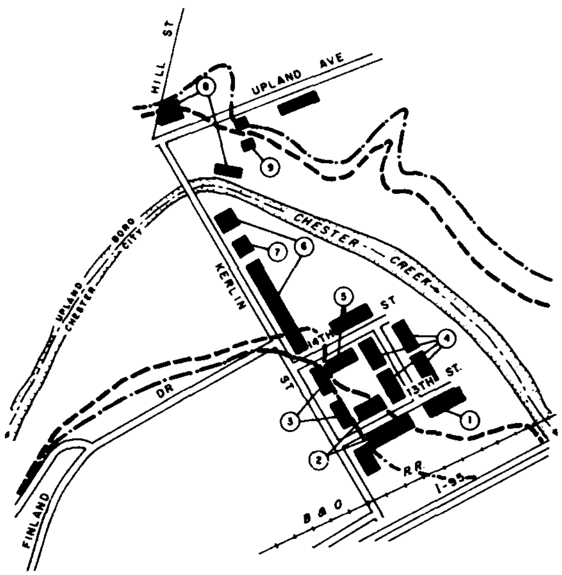
CHESTER CREEK BASIN, PENNSYLVANIA

FLOOD PRONE UNITS

DAMAGE SUB-REACHES 6A,6B&6C

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978




**LEGEND**

- 100-YEAR FLOOD PLAIN
- MUNICIPAL BOUNDARY
- STANDARD PROJECT FLOOD (SPF)

Not to Scale

| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 8A | 13th Street<br>500 Block, 10 homes | Residential |
| 2 | 8A | 13th Street<br>600 Block, 14 homes | Residential |
| 3 | 8A | Kerlin Street<br>1300 Block, 11 homes | Residential |
| 4 | 8A | Parker Street<br>1300 Block, 32 homes | Residential |
| 5 | 8A | 14th Street<br>600 Block, 12 homes | Residential |
| 6 | 8A | Kerlin Street<br>1400 Block, 22 homes | Residential |
| 7 | 8A | William Penn Gas Station<br>1457 Kerlin Street | Commercial |
| 8 | 8B | Upland Boats<br>801 Upland Avenue | Commercial |
| 9 | 8B | Engineering Services<br>and Construction<br>801 Upland Avenue | Commercial |

NOTES

1. Inventory based on September 1974 damage survey with January 1976 supplemental survey.
2. Buildings abandoned and removed prior to January 1976 are not included.

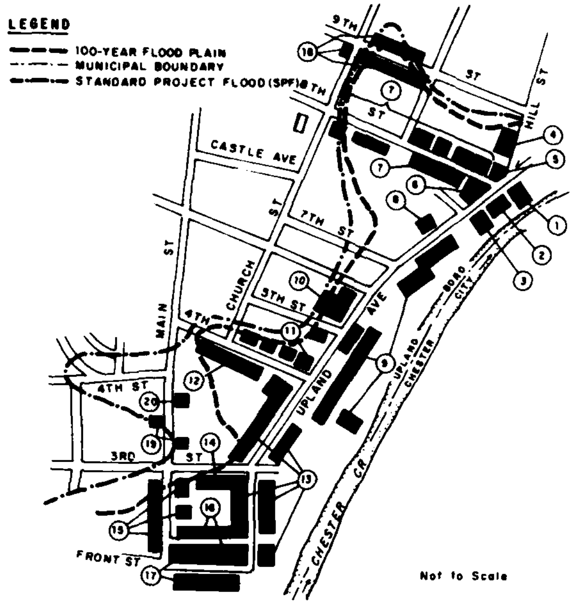
CHESTER CREEK BASIN, PENNSYLVANIA

FLOOD PRONE UNITS

DAMAGE SUB-REACHES 8A & 8B

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978




| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 9B | Sunoco Gas Station<br>S.E. Corner 8th and Upland | Commercial |
| 2 | 9B | Ed's Auto Body<br>775 Upland Avenue | Commercial |
| 3 | 9B | Upland Fire Company<br>8th and Upland Avenue | Public |
| 4 | 9B | Hill Street<br>Unit Block, 5 homes | Residential |
| 5 | 9B | Upland Washmatic<br>Hill and Upland Avenues | Commercial |
| 6 | 9B | Upland Auto Parts<br>S.W. 8th and Upland | Commercial |
| 7 | 9B | 8th Street<br>Unit Block, 20 homes | Residential |
| 8 | 9B | Marine Corps Club<br>Upland Avenue | Public |
| 9 | 9B | Pennway Industrial Park<br>Upland Avenue | Industrial |
| 10 | 9B | Upland Industries Plant #1<br>115 6th Street | Industrial |
| 11 | 9B | Gallen's Friendly Store<br>4th and Upland | Commercial |
| 12 | 9B | 4th Street<br>Unit Block, 23 homes | Residential |
| 13 | 9B | Upland Avenue<br>Unit Block, 32 homes | Residential |
| 14 | 9B | 3rd Street<br>Unit Block, 14 homes | Residential |
| 15 | 9B | Main Street<br>Unit Block, 18 homes | Residential |
| 16 | 9B | 2nd St., Unit Block, 12 homes | Residential |
| 17 | 9B | Front St., Unit Block, 17 homes | Residential |
| 18 | 9B | 9th Street<br>200, 300 Block, 21 homes | Residential |
| 19 | 9B | 21, 23, 320 Main St., 3 homes | Residential |
| 20 | 9B | Upland Baptist Church<br>4th and Main Streets | Public |

**NOTES**

1. Inventory based on September 1974 damage survey with January 1976 supplemental survey.
2. Buildings abandoned and removed prior to January 1976 are not included.

**CHESTER CREEK BASIN, PENNSYLVANIA**

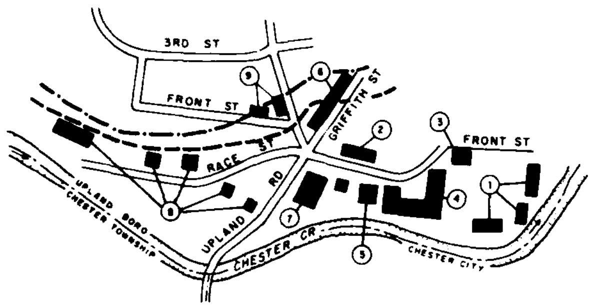
**FLOOD PRONE UNITS**

**DAMAGE SUB-REACH 9B**

**PHILADELPHIA DISTRICT, CORPS OF ENGINEERS**

**SEPTEMBER 1978**

PLATE C-20




LEGEND

100-YEAR FLOOD PLAIN
MUNICIPAL BOUNDARY
STANDARD PROJECT FLOOD (SPF)

Not to Scale

| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 9D | Upland Industrial Park Buildings 1, 2, 3 | Industrial |
| 2 | 9D | Ship & Shore Outlet #1 Race Street | Commercial |
| 3 | 9D | Harry Alexander Auto Sales Front and Main Streets | Commercial |
| 4 | 9D | Upland Industries Plant #2 Front and Main Streets | Industrial |
| 5 | 9D | ORB Industries #2 Race Street | Industrial |
| 6 | 9D | Griffith Street 100-506, 14 homes | Residential |
| 7 | 9D | J. W. Caldwell Corporation Race and Upland Avenue | Industrial |
| 8 | 9D | Caleb Pusey House Race Street | Public (Historical) |
| 9 | 9D | Front Street 500-506 4 Homes | Residential |

NOTES

1. Inventory based on September 1974 damage survey with January 1976 supplemental survey.
2. Buildings abandoned and removed prior to January 1976 are not included.

CHESTER CREEK BASIN, PENNSYLVANIA

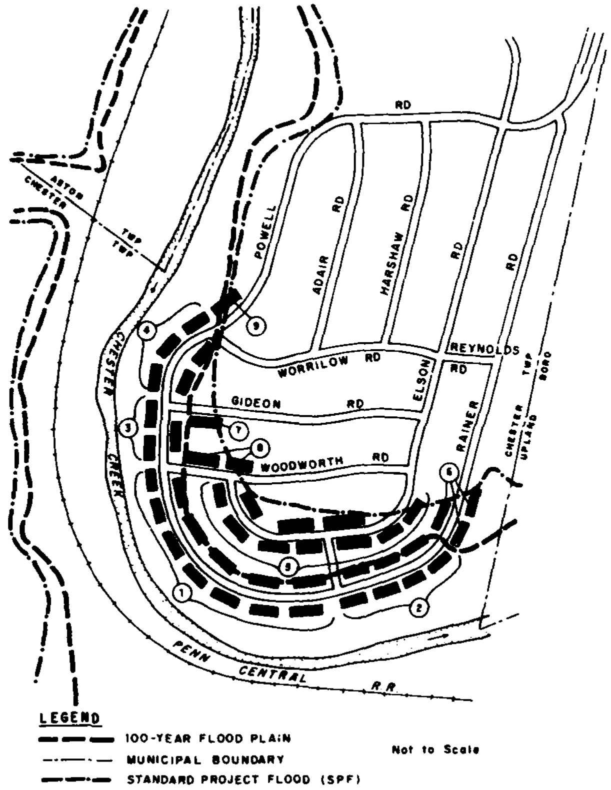
FLOOD PRONE UNITS

DAMAGE SUB-REACH 9D

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

PLATE C-21




| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 10B | Powell Road 1600 Block, 84 homes | Residential |
| 2 | 10B | Rainer Road 1500 Block, 28 homes | Residential |
| 3 | 10C | Powell Road 1500 Block, 12 homes | Residential |
| 4 | 10C | Powell Road 1400 Block, 24 homes | Residential |
| 5 | 10B | Elson Road 1500, 3900, 4000 Blocks, 61 homes | Residential |
| 6 | 10B | Ranier Road 1400 Block, 25 homes | Residential |
| 7 | 10C | Gideon Road 4042-4046, 3 homes | Residential |
| 8 | 10C | Woodworth Road 4015-4043, 14 homes | Residential |
| 9 | 10C | Powell Road 1360-1372, 7 homes | Residential |

**NOTES**

1. Inventory based on September 1974 damage survey with January 1976 supplemental survey.
2. Buildings abandoned and removed prior to January 1976 are not included.

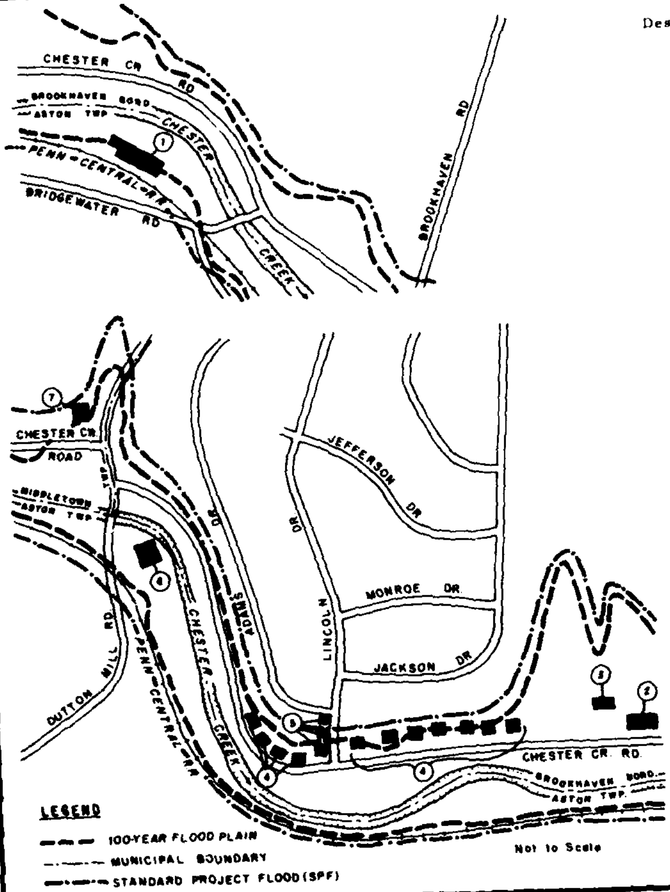
CHESTER CREEK BASIN, PENNSYLVANIA

FLOOD PRONE UNITS

DAMAGE SUB-REACHES 10B & 10C

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978



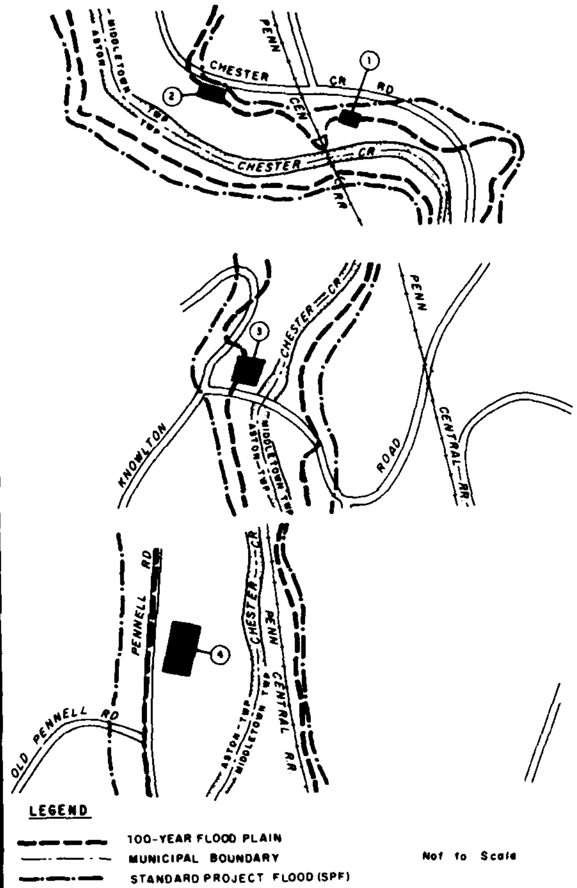

| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 11C | American Rendering Inc.<br>Bridgewater and Creek Road | Industrial |
| 2 | 11D | Skateland<br>Chester Creek Road | Commercial |
| 3 | 11D | Brookhaven Swim Club<br>Chester Creek Road | Public |
| 4 | 11E | Creek Road<br>4935-5007, 11 homes | Residential |
| 5 | 11E | Lincoln Road<br>841, 839, 826, 3 homes | Residential |
| 6 | 11E | Perlite<br>200 Dutton Mill Road | Industrial |
| 7 | 12B | John Woodward Contractor<br>Dutton Mill and Creek Road | Commercial |

NOTES

1. Inventory based on September 1974 damage survey with January 1976 supplemental survey.
2. Buildings abandoned and removed prior to January 1976 are not included.

CHESTER CREEK BASIN, PENNSYLVANIA
FLOOD PRONE UNITS
DAMAGE SUB-REACHES 11C, 11D, 11E & 12B
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1976

PLATE C-23

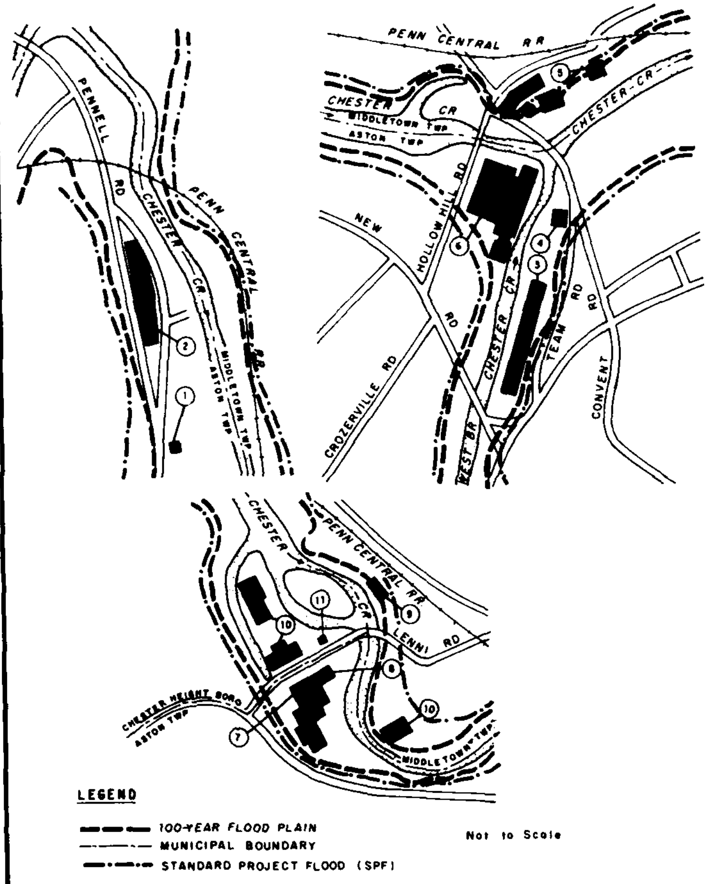



| Unit Designation | Damage | Unit | Category |
|---|---|---|---|
| 1 | 12D | 646 Creek Road<br>Middletown Twp., 1 home | Residential |
| 2 | 12D | Creek and Knowlton Road<br>Middletown Twp., 1 home | Residential |
| 3 | 13A | N. F. Verratti, Inc.<br>450 Knowlton Road | Commercial |
| 4 | 14A | R & D Machine Shop<br>Pennell Road Glen Riddle | Industrial |

NOTES
1. Inventory based on September 1974 damage survey with January 1976 supplemental survey.
2. Buildings abandoned and removed prior to January 1976 are not included.

CHESTER CREEK BASIN, PENNSYLVANIA
FLOOD PRONE UNITS
DAMAGE SUB-REACHES 12D,13A&14A
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE C-24




| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 14A | Pennell Road<br>#1 and #10, 2 homes | Residential |
| 2 | 14A | Ahrens Lumber<br>Rt. 452 Glen Riddle | Commercial |
| 3 | 16A | Flextron<br>720 Mount Road, Rockdale | Industrial |
| 4 | 16A | Flat Iron Tavern<br>Mount and Chester Creek<br>Rockdale | Commercial |
| 5 | 16B | John L. Blosenski & Son<br>222 Lenni Road, Glen Riddle | Commercial |
| 6 | 16B | Container Research Corporation<br>Hollowhill Road, Glen Riddle | Industrial |
| 7 | 17A | Ormsby & Pierce Inc.<br>Lenni and New Road | Industrial |
| 8 | 17A | Dawn Builders<br>Lenni Road | Commercial |
| 9 | 17B | Lenni Road<br>451-457 and 95, 5 homes | Residential |
| 10 | 18A | West Lake Plastics Co.<br>West Lenni Road | Industrial |
| 11 | 18A | Lenni Road<br>One home | Residential |

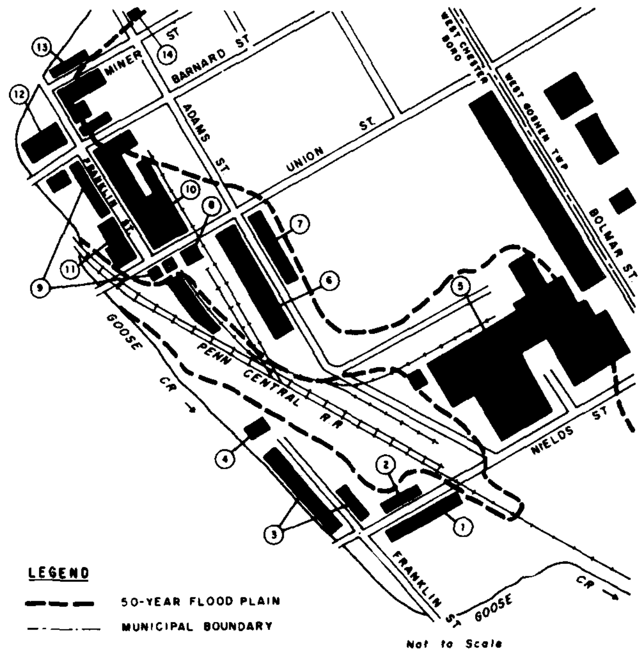
NOTES

1. Inventory based on September 1974 damage survey with January 1976 supplemental survey.
2. Buildings abandoned and removed prior to January 1976 are not included.

CHESTER CREEK BASIN, PENNSYLVANIA
FLOOD PRONE UNITS
DAMAGE SUB-REACHES 14A,16A,16B,17A,17B&18A
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

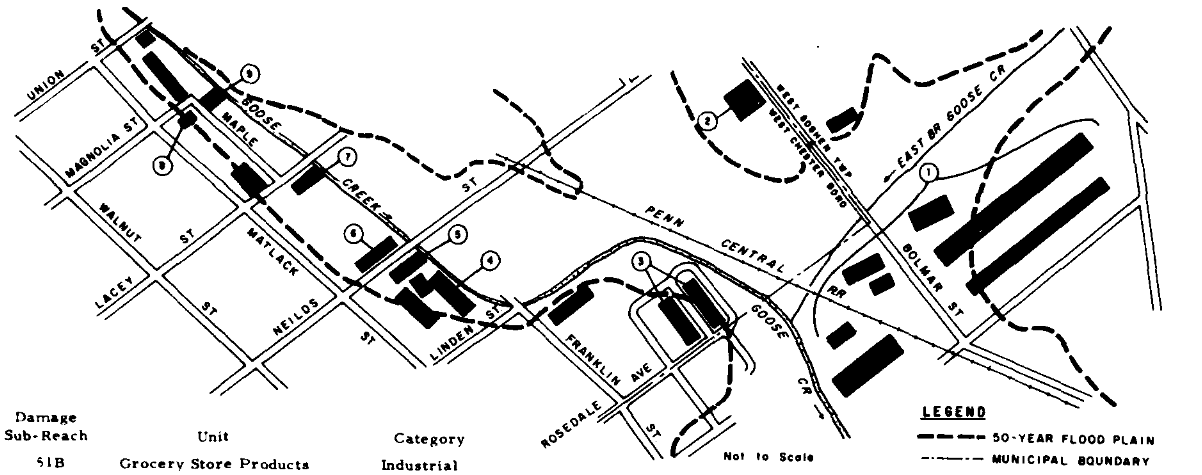
| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 51B | Nields Street<br>386-510, 14 homes | Residential |
| 2 | 52B | E. Nields Street<br>385-437, 6 homes | Residential |
| 3 | 52B | S. Franklin Street<br>500-526 and 535-539, 13 homes | Residential |
| 4 | 52B | Empty Building,<br>Lacey and Franklin | Commercial/<br>Industrial |
| 5 | 52B | Wyeth Laboratories<br>611 E. Nields Street | Industrial |
| 6 | 52B | National Foam System Inc.<br>Union and Adams | Industrial |
| 7 | 52B | Adams Street<br>301-355, 15 homes | Residential |
| 8 | 52B | Union Street<br>300 Block, 5 homes | Residential |
| 9 | 52B | J. Leon Haggerty<br>300 E. Union Street | Commercial |
| 10 | 53B | Hoffman Lumber Company<br>Union and Franklin Streets | Commercial |
| 11 | 53B | Broad Run<br>Union and Franklin Streets | Commercial |
| 11 | 53B | Halls Auto Body Shop<br>Franklin and Union Streets | Commercial |
| 11 | 53B | Conservation Association<br>Franklin and Union Street | Commercial |
| 12 | 54B | Nachman Corporation<br>Barnard Street | Industrial |
| 13 | 54B | E. Miner<br>301-315, 8 homes | Residential |
| 14 | 54B | Adams Street<br>13-15, 2 homes | Residential |

NOTES
1. Inventory based on September 1974 damage survey with January 1976 supplemental survey.
2. Buildings abandoned and removed prior to January 1976 are not included.
3. Only the 50 year flood outline is shown because the 100 year and SPF events are fairly close to the 50 year flood outline and, also, the flood of record was approximately a 50 year flood.




CHESTER CREEK BASIN, PENNSYLVANIA
FLOOD PRONE UNITS
DAMAGE SUB-REACHES 51B,52B,53B&54B
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE C-26




| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 51B | Grocery Store Products<br>Union and Adams | Industrial |
| 2 | 51B | Sartomer Resins<br>Bolmar Street | Industrial |
| 3 | 51A | Penn Street<br>700 Block, 29 homes | Residential |
| 4 | 51A | Franklin Street<br>C31-C38, 8 Apts. Unit Block | Residential |
| 5 | 51A | Nields<br>200 Block, 4 homes | Residential |
| 6 | 52A | Nields<br>200 Block, 5 homes | Residential |
| 7 | 52A | Lacey Street<br>220-222, 2 homes | Residential |
| 8 | 52A | Magnolia<br>14, 16 and 09, 3 homes | Residential |
| 9 | 52A | Maple Alley<br>224-226, 2 homes | Residential |

**NOTES**

1. Inventory based on September 1974 damage survey with January 1976 supplemental survey.
2. Buildings abandoned and removed prior to January 1976 are not included.
3. Only the 50 year flood outline is shown because the 100 year and SPF events are fairly close to the 50 year outline and, also, the flood of record was approximately a 50 year flood.

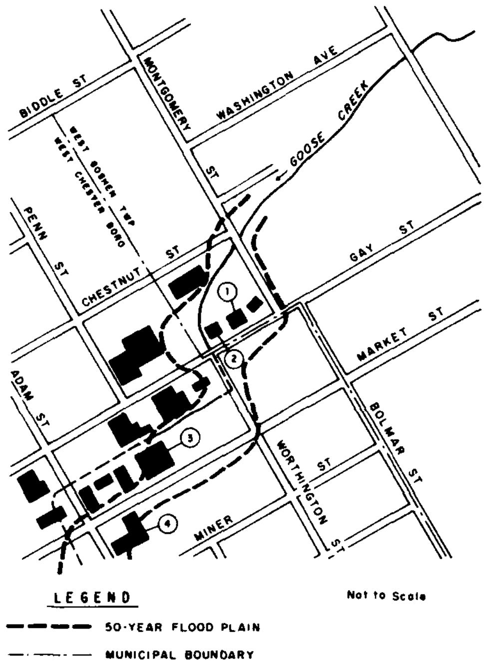
CHESTER CREEK BASIN, PENNSYLVANIA

FLOOD PRONE UNITS

DAMAGE SUB-REACHES 51A, 51B & 52A

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978



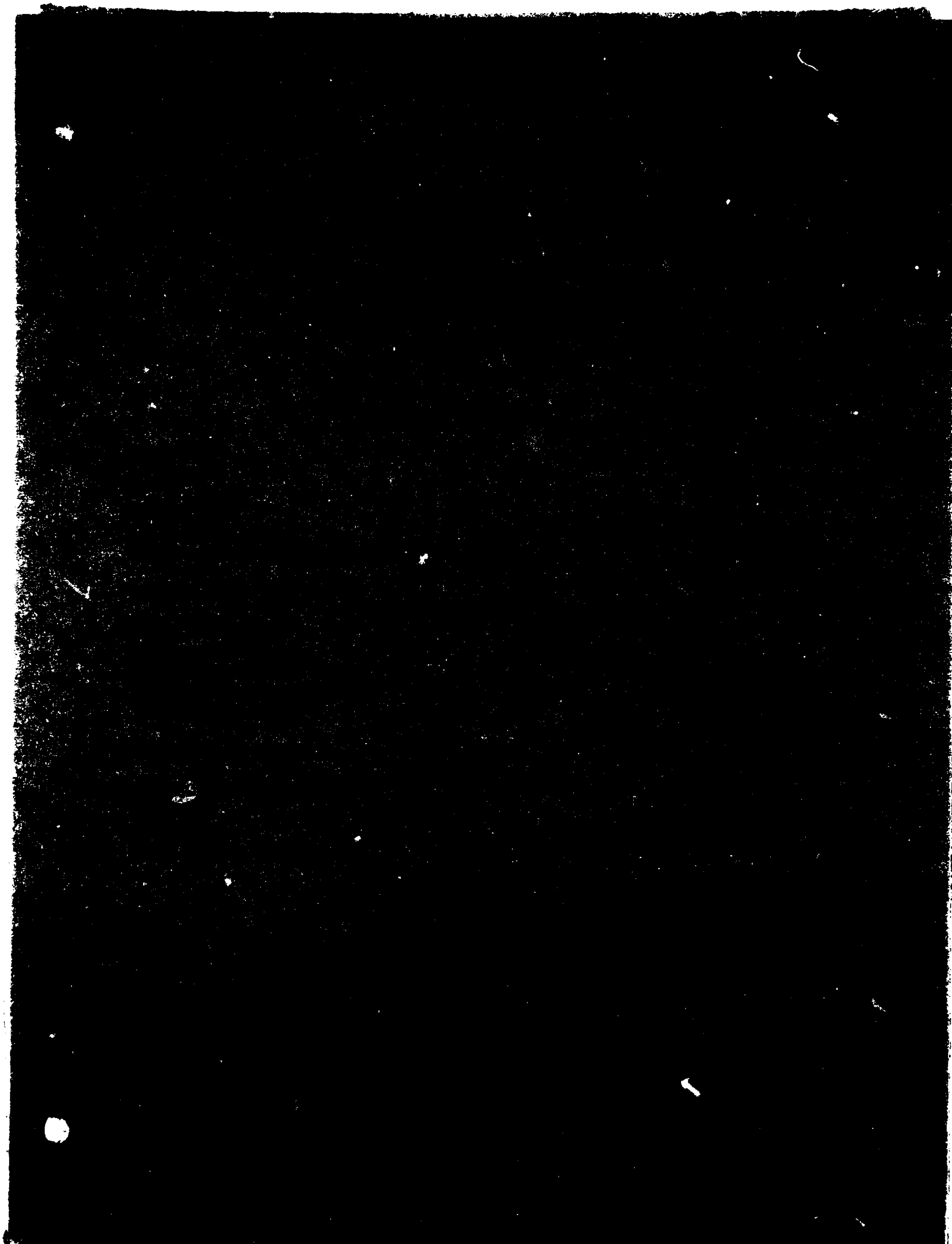

| Unit Designation | Damage Sub-Reach | Unit | Category |
|---|---|---|---|
| 1 | 55 | West Chester Bicycle Center<br>621 Gay Street | Commercial |
| 1 | 55 | Thimm Automotive<br>619 Gay Street | Commercial |
| 2 | 55 | Davis Kappe Diner<br>Gay Street | Commercial |
| 3 | 55 | Gotter's Auto Repair<br>517 E. Market Street | Commercial |
| 3 | 55 | Carlson's Auto Body Works<br>515 E. Market Street | Commercial |
| 4 | 54B | West Chester Automotive | Commercial |

NOTES

1. Inventory based on April 1976 supplemental damage survey.
2. Only the 50 year flood outline is shown because the 100 year and SPF events are fairly close to the 50 year outline and, also, the flood of record was approximately a 50 year flood.

CHESTER CREEK BASIN, PENNSYLVANIA
FLOOD PRONE UNITS
DAMAGE SUB-REACHES 54B & 55
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE C-28



SECTION D

# FORMULATING A PLAN

1. This section covers the general goals, methodology and criteria used in the formulation and evaluation of alternative flood control plans and description of the plans considered. All solutions which were considered but were eliminated following preliminary investigations are discussed in the sub-section titled POSSIBLE SOLUTIONS. Those plans which warranted more detailed studies are presented in sub-sections titled: PLANS CONSIDERED. Forty-seven plans were considered including Basin-wide, Local Flood Water/Storm Drainage plans and Combinations of these plans. Information given for each plan includes description: technical analysis and design; hydraulic performance; economic performance; environmental, social, and economic effects; coordination for local assurances when applicable; and conclusions. The results of coordination on plans which were recommended for further consideration is presented in the sub-section titled: INSTITUTIONAL STUDIES. The last sub-section discusses the alternative plans which were CONSIDERED FURTHER.

## INTRODUCTION

2. The objective of the Study was to develop a flood control plan for the Chester Creek Basin. Water supply and recreational development were considered, but only as secondary planning objectives. Further investigations resulted in the refinement of the study objectives and scope as defined in the Plan of Study.* The following is the scope for which the study was conducted:

> FLOOD CONTROL. Project planning to solve flooding problems in the Chester Creek Basin will be investigated at survey level of detail. In the area of urban drainage, the responsibility for the detailed planning, design and construction rests with local governments. Therefore, if it is determined that urban drainage plans are needed they will only be developed in this study to the level of detail necessary to identify the plans and determine the plans' impact on flood control solutions.

* Metropolitan Chester Creek Basin, Plan of Study, Philadelphia District, U.S. Army Corps of Engineers; November, 1974; revised July, 1975.

WATER SUPPLY. If it is determined during the conduct of this study that certain alternatives, which are being formulated to solve flooding problems, also have multi-purpose capacity to include water supply, this study may be expanded to conduct such investigations in accordance with the Water Supply Act of 1958 (Public Law 500, 85th Congress, Title III), as amended.

RECREATION. This study will only focus on providing recreational facilities and preserving open space areas and natural resources within the context of plans developed for flood control. Therefore, this study will only investigate the possibility of recreational development in conjunction with potential plans formulated to solve the flooding problems.

OTHER WATER RESOURCES. This study's major task will be to coordinate this study with all other water resources planning efforts in the Basin. This will insure that any plans developed as a result of this study will be compatible with plans developed by other ongoing efforts.

## PLAN FORMULATION

3. Formulation and evaluation of alternatives were carried out in four cycles. The detail of the investigations increased with each succeeding cycle.

4. CYCLE ONE. The initial cycle was the identification and preliminary consideration of all possible measures for eliminating or reducing flood-related problems. All measures were reviewed to see if they could be modified to also satisfy water supply and recreation needs. These investigations were conducted at a conceptual or low level of detail. All structural and non-structural flood control measures were studied to determine their practicality for the Basin. Measures which were technically infeasible or obviously too costly were eliminated from further consideration.

5. CYCLE TWO. In the second cycle physical and economic performance and potential impacts of the plans were measured and evaluated. Physical performance was investigated first. Physical performance for flood control was measured by decreases in discharges, decreased in stages and increases in level of protection. For water supply, measurement of performance was the expectation to meet demands in a more efficient manner than other future sources. Recreation performance was determined by the ability to satisfy the types of recreation which are needed.

6. Economic performance was next measured by the amount of benefits to be derived and the ability to achieve the benefits for an equal or

lower cost. This was measured by comparing the (NED) economic benefits to the economic costs. In Cycle 2 a minimum benefit to cost ratio (BCR) of 0.8 was required. However this had to be supported with the prospect that more detailed investigations would result in a BCR greater than 1.0. Average annual benefits were calculated for base year (1985) conditions*. Equivalent average annual benefits were calculated for urbanizing Basin conditions with affluence of residential contents but with no growth in the flood plain.

7. Assessments of the likely major or critical impacts of each plan were conducted. Major or critical impacts were defined as those which: make a plan unacceptable; result in substantial benefits not calculated such as conservation, fish and wildlife enhancement or aesthetics; change primary components of the plan; or require mitigation costs which would obviously make the plan unjustified. The assessments were based on an environmental, social and economic profile developed for the Basin as part of the study and input provided by the United States Fish and Wildlife Service.

8. Studies in Cycle 2 were conducted for forty-seven plans. Many other variations of these forty-seven were eliminated prior to completing Cycle 2 because of poorer performance. Twelve of the forty-seven plans indicated potential and were recommended for further consideration. No plans were eliminated at this point solely because of adverse social, environmental, regional or economic impacts.

9. CYCLE THREE. The third cycle involved an institutional and implementation analysis. All alternatives which were investigated in Cycle 2 were coordinated with local, county and state officials and later presented to the public. A statement as to fiscal capability and intent to provide local assurances were sought for the twelve plans which were recommended for further consideration. Ten plans did not receive sponsorship and were eliminated from further consideration.

10. CYCLE FOUR. The fourth and final cycle consisted of more detailed technical and economic investigations of the two alternative plans for which an intent of local sponsorship was received. More detailed impact assessments were not conducted since neither plan was found to be economically justified.

## FORMULATION AND EVALUATION CRITERIA

11. Flood control plans were formulated and evaluated on the basis of technical, economic, environmental, and socio-economic and

* Base year refers to the predicted year when a project would be operational.

implementation criteria. This includes all of the criteria specified in the "Principles and Standards for Planning Water and Related Land Resources," Section 122 of the "River and Harbor and Flood Control Act of 1970," Corps of Engineers regulations (200 series) for Civil Works; and the National Environmental Policy Act of 1969. All were considered in the formulation and evaluation of alternative solutions. Specific criteria were established for application to all alternatives being considered. These criteria are presented in the following paragraphs.

12. TECHNICAL CRITERIA. The following technical criteria were adopted for use in developing and analyzing flood protection alternative plans:

Protection should be provided against a design storm equal to the Standard Project Flood due to the urban nature of the area and the threat to life which would be caused by failure of protective works;

Protection should be provided against a design flood equal to or greater than the flood of record;

Protective works should be designed to prevent failure up to the design flood;

Protection must function without causing adverse effects in other areas;

Freeboard on levees and floodwalls would be 3 and 2 feet, respectively; and

Openings under new bridges would be adequate to pass a minimum of a 100-year flood without backup.

13. ECONOMIC CRITERIA. The following criteria applied in the formulation and evaluation of flood protection plans:

Tangible benefits exceed economic costs. Measurement was based on the NED benefit-cost ratio being greater than 1.0 to 1.

Each spearable unit or purpose provides benefits at least to its costs. (Local protection plans must be justified on the basis of flood control benefits prior to modifications for other purposes.)

The scope of the development is such as to provide the maximum net benefits including environmental, social, and intangible considerations.

There is no more economical means, evaluated on a comparable basis, of accomplishing the same purpose or purposes which would be precluded from development if the plan were undertaken. This criteria refers only to those alternative possibilities that would be physically displaced or economically precluded from development if the plan is undertaken.

14. It was assumed that no further development will take place in the 100-year flood plain unless it is either above the 100-year flood elevation or flood proofed to that elevation. No future inundation damages were therefore assumed to result from future development in the flood plain.

15. The benefits and cost are expressed in comparable terms to the fullest extent possible. All of the alternatives considered are evaluated based on an discount rate of 6-1/8 percent (and 8 and 10 percent for some) and a project life of 50 years (and 100 years for some). The study year is 1975. It was assumed initially that a selected plan of improvement could be operative by 1980 and have an economic life to 2030. All decisions whether to recommend plans for further consideration and whether to provide local sponsorship were based on these results.

16. The two plans which were conisdered further in Cycle 4 were analyzed at January 1978 prices; 6-5/8 percent interest; 1977 study year; base year of 1985; and a 50 year economic life.

17. ENVIRONMENTAL AND SOCIO-ECONOMIC CRITERIA. The following environmental criteria and intangible effects were considered in formulation and evaluation of flood protection plans:

Protect public health, safety, and well-being, including possible loss of life.

Promote the development of pleasing aesthetics and other desirable environmental effects.

Avoidance, where possible, of detrimental environmental effects and inclusion of feasible mitigation features of such effects found unavoidable.

18. IMPLEMENTATION CRITERIA. The following implementation criteria were considered in formulation and evaluation of the flood protection plans:

Acceptance of the type of plan by the affected communities.

Following Stage II, local interests must indicate a capability to provide local assurances and indicate their intent to do so.

Local assurances must be provided for any plan being recommended to Congress.

# POSSIBLE SOLUTIONS

19. Many alternative plans were investigated. Due to the urban nature of the area and the high probability of loss of life and large damages, emphasis was placed on those plans which could provide SPF protection or at a minimum 100-year flood protection. Any flood control measures which would allow the area to still be flooded or which would only reduce damages by a small amount were not addressed in the same level of detail, since these types of plans would not satisfactorily achieve the planning objective. If applicable, they were considered to supplement the preventive measures or as a substitute if preventive alternatives were not found feasible or acceptable.

20. All of the measures which were conisdered are listed below. The letters (P) and (R) indicate that the measure was considered to be preventive or reductive, respectively.

STRUCTURAL

Bridge Modification and Replacements (P)

Bypass Channels (P)

Channel Modifications (deepening, widening and realignments of existing channels, or combinations of these) (P)

Drainage System Improvements (P)

Dry Detention Reservoirs (P)

Levees and Floodwalls (P)

Natural Channel Storage (natural impoundments) (P)

Permanent Pool Reservoirs (multi-purpose) (P)

Tidal Dams (P)

NON-STRUCTURAL

Contigency Flood Proofing (P)

Flood Forecasting (R)

Flood Insurance (R)

Regulatory Measures, Flood Plain Zoning and Floodway Ordinances (R)

Flood Preparedness Planning (R)

Flood Warning (R)

Land Development Regulations in Upland Areas (R)

Tax Adjustments or Acquisition of Development Rights (R)

Permanent Evacuation or Relocation (P)

Pervious Paving (R)

Temporary Evacuation (R)

21. MINOR DAMAGE AREAS. No individual-local alternative plans such as floodwalls and levees were considered for minor damage areas including sub-reaches 1A, 1B, 2A, and 2B. Potential benefits which would be acquired in these areas obviously could not justify average construction costs of these type projects. Sub-reaches 3A and 3B have substantial damages that may have allowed some major expenditures for protection; however, in order to protect this area from upstream overbank flows, the protection of 4A and 4B was also required to maintain the integrity of the system. This resulted in major additional construct costs with disproportionately little increases in potential benefits.

22. NATURAL CHANNEL STORAGE. Natural channel storage was considered in two basin-wide concepts. The one concept was from the viewpoint that future flood plain development would reduce natural storage; thereby, increasing flooding. A review was made to see if the flooding could be reduced by insuring natural storage by acquisition in fee or development rights. Increasing efficiency was then attempted by inducing in-stream storage earlier with a series of in-stream devices such as weirs. It became obvious that neither concept could be justified solely on flood control benefits.

23. TIDAL DAMS. The influence of high tides on flooding in Chester Creek is very minimal and localized. Increased stages of fluvial flooding due to above normal tides dissipates within a few hundred feet above the mouth of the Creek. Benefits accrued within the first few sub-reaches could not justify expenditures for a tidal dam.

24. REGULATORY MEASURES, FLOOD PLAIN ZONING AND FLOODWAY ORDINANCES. A review was made of regulatory measures, zoning and ordinances in existance or typically being adopted to meet National Flood Insurance Program requirements for the communities in the Basin. They satisfy normal proper flood plain management practices. More stringent or expansive requirements would not eliminate or reduce existing flood

damages. Greater requirements would eliminate or reduce increases in future damages but in comparison to the existing problem, it would be small. Implementation of stronger requirements is a local responsibility. These measures were eliminated from further consideration.

25. LAND DEVELOPMENT REGULATIONS IN UPLAND AREAS AND PERVIOUS PAVING. These measures are meant to retard stormwater runoff from stream flood flows. The major impact of these measures is to reduce future increases in flooding which are predicted to occur and are shown in the urbanization analysis conducted as part of this study. These measures have limited effect on existing problems. Implementation of these measures is a local responsibility. These measures were eliminated from further consideration.

## PLANS CONSIDERED

### BASIN-WIDE PLANS

26. The alternatives presented in this sub-section were considered for general application for major portions of the Basin.

27. FLOOD INSURANCE. Flood insurance offers property owners a means of avoiding catastrophic losses due to floods. Flood insurance provides for reimbursement of possible financial losses at the cost of payment of a regular premium. In addition to financial protection, the flood insurance program encourages wise use of flood hazard lands to help reduce future flood losses. Flood insurance does not eliminate the flood hazard and is limited in the amount of financial loss that may be covered by a policy.

28. The limit of coverage under the Emergency and Regular Programs is summarized below. The first layer is available at subsidized rates and the second layer at actualurial rates.

| | First Layer Limit | Second Layer Limit | Total Limit |
|---|---|---|---|
| Single Family Residential | $ 35,000 | $ 35,000 | $ 70,000 |
| Other Residential | 100,000 | 100,000 | 200,000 |
| Non-Residential | 100,000 | 100,000 | 200,000 |
| Contents, Residential (per unit) | 10,000 | 10,000 | 20,000 |
| Contents, Non-Residential (per unit) | 100,000 | 100,000 | 200,000 |

Only the first layer of coverage is available under the Emergency Program, but both are available under the Regular Program. Most homes in the Basin could be adequately covered by the Regular Program and many could be adequately covered within the first layer limits. It appears that the Regular Program could also provide sufficient coverage for most multi-unit residences, commercial buildings, and small industries in the Basin. However, even with first and second layers of coverage at their *maximum* levels, the larger industries in the Basin would be underinsured. Flood insurance does not eliminate the cost of cleanup required after a flood. Because the flood hazard remains, the threat to public safety and loss of life is still present.

29. The payment of the flood insurance premium calls the degree of flood risk to property owners' attention in one of the most effective methods short of a flood. Presumably this easily recognizable cost will encourage the modification of use and/or eventually abandonment of hazardous areas. Conversely, the availability of insurance and avoidance of catastrophic loss may encourage continued occupancy in the flood plain in some cases.

| FI1 | FLOOD INSURANCE |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Provides protection against catastrophic individual financial losses

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** No effect

**DAMAGE LEVELS** Increase from the present $13,940,000 to $18,600,000 over the next 50 years. Insured damages would be reimbursed

## ECONOMICS

·As of August 1975, 540 policies were in effect in the 21 municipalities in the Chester Creek Basin. These policies, insure against damages caused by several streams in addition to the Chester Creek. Of the more than 900 residences, businesses, and industries located within Chester Creek's 100 year flood plain, less than half have flood insurance.

·Even if all of the buildings along the Chester Creek were insured, a major portion of flood damages can not be insured against.

·Flood insurance can not be purchased for roads, bridges, utilities, motor vehicles, boats, lawns, trees, shrubs, and personal property in the open. Emergency and clean up costs also can not be insured against. The first $200 or 2% of the damages (whichever is greater) is paid by the policy holder. This clause applies separately to the building and its contents.

·Maximum amounts of structural plus content coverage available under the regular program include; single family dwellings, $70,000 plus $20,000; multi-family dwellings $200,000 plus $20,000 per unit; and all other properties, $200,000 plus $200,000.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

·A slow reduction of flood related problems due to reimbursement of losses.

·A reduction in psychological stresses from the threat of floods.

·Some reduction in deterioration of existing flood plain structures.

·Continued destruction of the stream bank and flood plain environment through erosion of banks and deposition of silts and debris.

·Permanent open space due to flood plain zoning.

## REGIONAL / ECONOMIC EFFECTS (major)

·A minimization of the disruptive economic effects of floods.

·A decrease in the tax base, employment and population caused by restricted economic growth in flood plain lands.

·Annual administrative costs for the insurance program and land use controls.

## CONCLUSIONS

From a national perspective flood insurance is justified on the basis of future land use regulations in the flood plain and social benefits. Promotion of the National Flood Insurance Program is a local responsibility.

| FI1 | FLOOD INSURANCE |
| --- | --- |

## DESCRIPTION

**PLAN** This plan promotes the National Flood Insurance Program and seeks 100% participation. The Program does not reduce damages, but it does reimburse flood victims for a large portion of the damages suffered. Although it provides no physical improvements, the Program requires implementation of flood plain zoning regulations. These regulations, when properly enforced, guide the use of the flood plain so that future damages are kept at a minimum. Even with flood plain zoning the annual damages to existing properties are expected to double by the year 2035. The amount of insurance coverage should be increased.

**LOCATION** Entire Chester Creek Basin

**PROJECT LIMITS** West Chester to the Delaware River

**PROTECTION LIMITS** No protection is provided

NUMBER OF FLOOD INSURANCE POLICIES IN EFFECT
IN DELAWARE AND CHESTER COUNTIES

| | Number of Policies in Effect | | Type of Program 1/ |
| --- | --- | --- | --- |
| Delaware County | Aug 75 | Dec 77 | |
| Aston Township | 7 | 30 | E |
| Bethel Township 2/ | 0 | 0 | NP |
| Birmingham Township | 4 | 28 | E |
| Brookhaven Borough | 51 2/ | 42 | R |
| City of Chester | 196 2/ | 194 | E |
| Chester Heights Borough | 8 | 9 | E |
| Chester Township | 62 | 112 | E |
| Concord Township | 5 | 11 | R |
| Edgmont Township | 0 | 0 | R |
| Middletown Township | 19 | 32 | E |
| Parkside Borough | 2 | 4 | R |
| Thornbury Township | 2 | 10 | R |
| Upland Borough | 100 | 100 | R |
| Upper Chichester Township | 16 | 21 | R |
| Chester County | | | |
| Birmingham Township | 15 | 6 | E |
| East Goshen Township | 4 | 6 | R |
| Thornbury Township | 5 | 2 | R |
| West Goshen Township | 0 | 6 | R |
| West Chester Borough | 26 | 35 | R |
| Westtown Township | 2 | 6 | R |
| West Whiteland Township | 16 | 19 | R |

1/ Status as of Feb 1978. E, R, and NP indicate emergency program, regular program, and non-participant, respectively.

2/ A breakdown by stream was not available. Numbers include policies for other flood plains.

30. PERMANENT FLOOD PLAIN EVACUATION. The objective of evacuation is to remove people and damageable property from the flood hazard area. The practicality of evacuation depends upon the frequency and severity of flooding and upon the value of the property. Already, many of the structures which were flooded in 1971 have either been abandoned or demolished and removed. The Eyre Park residential section of the City of Chester was completely inundated in 1971 when the levee protecting it was overtopped. All 216 homes have been purchased by the City of Chester Redevelopment Authority; the residents relocated outside of the flood plain; and the homes demolished and removed. In addition, approximately 44 residential and 32 commercial or industrial properties in other parts of the Basin have been abandoned since 1971.

31. Evacuation was considered for all the major damage areas. A sampling technique was used in order to determine economic feasibility of individual structures (Plan E1). The samples were structures with high damage potential and relatively frequent flooding which would, therefore, result in high benefits and favor a project. Two other evacuation concepts (Plans E2 and E3) were investigated. These were for an entire area to determine if evacuation of a large area would result in economics of scale; increased hydraulic efficiency; or recreational land use potential. A summary of the reconnaissance of the potential for flood plain evacuation is presented in the following paragraphs.

32. The lower Basin below Ninth Street in the City of Chester (subreaches 1A through 5B), is characterized by brick or masonry structures many of which are 50 years old or more. Numberous abandoned structures are scattered throughout the area. Portions of this lower Basin, together with the waterfront along the Delaware River, have been proposed for redevelopment; thus, evacuation of selected structures would be consistent with redevelopment plans. Many of these structures were included in Plan E2. The resulting open land was considered appropriate for open space in the urbanized City of Chester or for parking for the City's Central Business District.

33. Immediately upstream from Ninth Street there are three structures--Chester High School, a YMCA, and Christopher Columbus Elementary School. Because of their size, condition, and location, evacuation is not practical.

34. The structures in Crozer Park Gardens are of brick construction and are generally in good condition; however, because of their great damage susceptibility those below the 100-year flood elevation were considered for removal in Plan E3. The creation of open spaces seemed appropriate for a continuation of a City park adjacent to this area.

35. Commercial and industrial structures in the Borough of Upland (subreaches 8B, 9B, 9D) area are generally in good condition, but some were considered for evacuation on a selective basis. Most of the residences inundated in 1971 are in fair to good condition.

36. The 131 Toby Farms residences (sub-reaches 10B and 10C) which were inundated in 1971 are townhouse brick-type structures which are in good condition. There was little expectation that annual damages would be high enough to warrant evacuation.

37. From above Toby Farms to the confluence of the West Branch of Chester Creek, the structures are scattered along the flood plain. Most residences are masonry and in good condition. The industrial structures are large and in good condition. It was apparent that their removal from the flood plain would not be economically justified.

38. Flooding in the Goose Creek area in the Borough of West Chester and West Goshen Township is of a frequent but low-stage, urban flooding nature. Most of the structures in the area are relatively new and in good condition. After comparing damages incurred with the physical condition and value of the structures, it was obvious that their evacuation was not economically justified.

39. Evacuation can aid in developing a "greenbelt" along the Chester Creek. Facilities for hiking, bicycling, picnicking, athletics, municipal parking, and other compatible uses such as boat launching were considered. It became obvious that flood control benefits were secondary. They were not as great as the benefits which could be realized from other purposes. Flood control benefits should be considered as strong secondary benefits if the areas are being considered for other purposes such as redevelopment, open spaces, conservation and intense recreational development.

| E1, E2, E3 | PERMANENT FLOOD PLAIN EVACUATION |
|---|---|

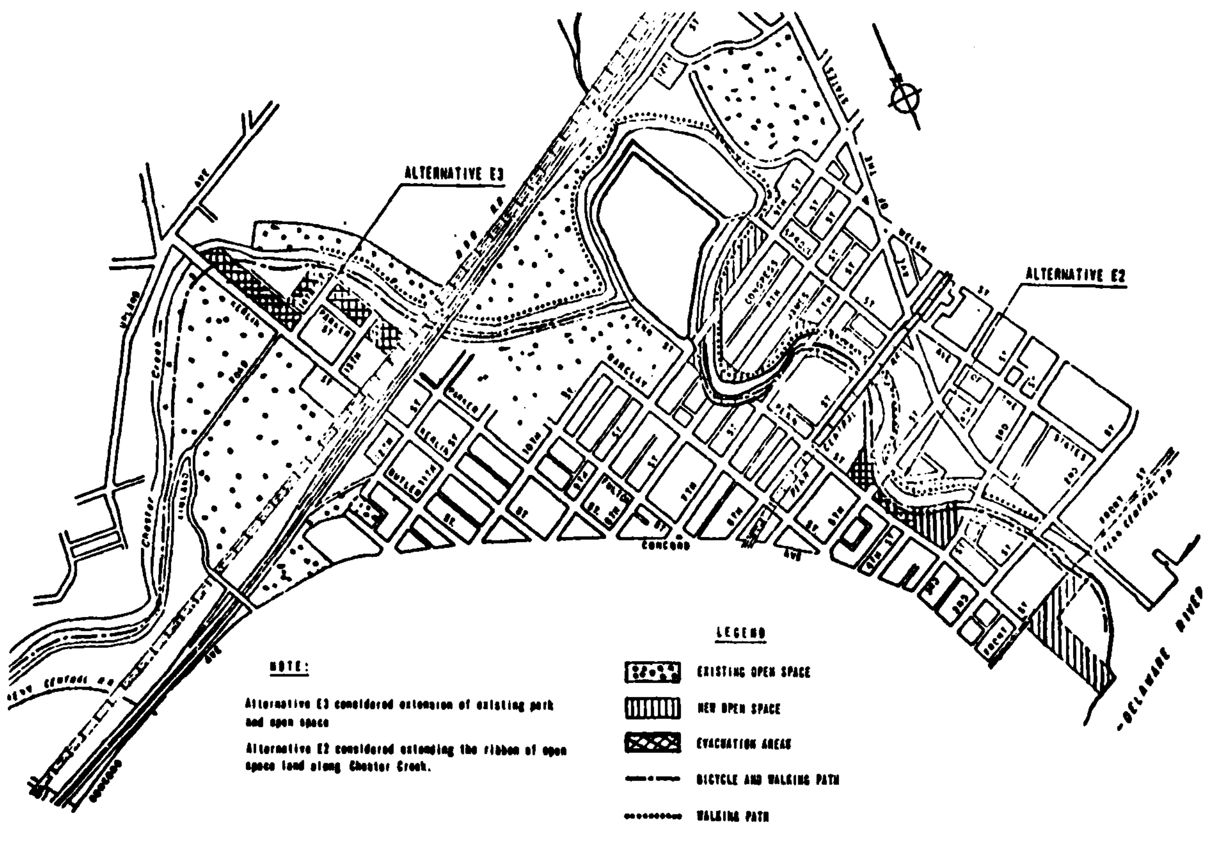
## DESCRIPTION

**PLAN** Plan E1 involves the relocation of all flood plain homes and businesses, which could be economically justified on an individual basis, to comparable non-flood plain sites. Evacuation buildings would be acquired and demolished. Plan E2 would evacuate 8 businesses (5 buildings) in the City of Chester. This would also increase the flow capacity of the Creek. The evacuated area could be used as open space, a parking area, or other compatible uses. Plan E3 would evaluate 60 homes and 1 business at Crozer Park Gardens in the City of Chester. The evacuated area would be used as park land, contiguous to Crozer Park.

**LOCATION** E1 - sites scattered throughout Chester Creek Flood Plain; and E2 & E3 City of Chester.

**PROJECT LIMITS** E1 - West Chester to Delaware River; E2 - below 3rd St. to above 5th St., City of Chester; & E3 - B&O railroad to Kerlin St., City of Chester.

**PROTECTION LIMITS** E1 and E3 - Evacuated structures only; and E2 - 3rd Street to immediately above 5th Street, City of Chester.



| E1, E2, E3 | PERMANENT FLOOD PLAIN EVACUATION |
|---|---|

## PHYSICAL PERFORMANCE

LEVEL OF PROTECTION Complete to those buildings permanently evacuated

EFFECT ON THE 100 YEAR FLOOD

FLOODING LEVELS Slight reduction in areas immediately upstream of evacuated area

DAMAGE LEVELS Elimination of damage to the buildings involved

## ECONOMICS

| | E1* | E2 | E3 |
|---|---|---|---|
| PROJECT COST (TOTAL) | $18,080 to 506,370 | $852,000 | $2,132,000 |
| construction | * | 40,000 | 242,000 |
| lands and relocation | * | 807,000 | 1,882,000 |
| recreation | 0 | 5,000 | 8,000 |
| AVERAGE ANNUAL COSTS (TOTAL) | $1,167 to 32,686 | $ 55,000 | $ 137,600 |
| interest and amortization | 1,167 to 32,686 | 55,000 | 137,600 |
| operation and maintenance | ** | ** | ** |
| AVERAGE ANNUAL BENEFITS (TOTAL) | $ 55 to 8,045 | $ 23,100 | $ 68,700 |
| flood control | 55 to 8,045 | 10,600 | 47,900 |
| recreation | 0 | 12,500 | 20,800 |
| BENEFIT / COST RATIO | | | |
| FLOOD CONTROL ONLY | 0.03 to 0.44 | 0.19 | 0.35 |
| FLOOD CONTROL & RECREATION | 0 | 0.42 | 0.50 |

* Ranges for 11 samples investigated

** Not estimated due to obvious economic infeasibility

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Elimination of flood related problems for those people whose buildings are evacuated.
- Elimination of psychological stresses from the threat of floods for those evacuated.
- Increase opportunity for recreation, conservation, and natural development.
- Elimination of portions of neighborhoods.

## REGIONAL / ECONOMIC EFFECTS (major)

- Elimination of annual flood damages of buildings permanently evaluated.
- Adverse changes in business and community development patterns.
- Restriction in economic growth in flood plain lands.
- A decrease in the tax base, employment and population due to changes in use of flood plain land.

## CONCLUSIONS

These plans cannot be economically justified solely for flood control and have major adverse social & economic effects. The Corps of Engineers cannot participate; therefore, they are eliminated from further consideration. Flood control should be considered a secondary benefit for areas developed for other purposes.

40. FLOOD PROOFING. Flood proofing is designed to protect damageable property from floodwaters by preventing the water from entering the structure. This can be done by raising the structure; providing perimeter protection (levee or floodwall) around the structure; or sealing the structure. Raising structures is more applicable to structures of frame construction which are not excessively large. Most of the structures in the Chester Creek flood plain are of a masonry or brick construction. Many are large commercial or industrial buildings or row homes. Raising structures was not feasible for most of the structures in the Basin.

41. Flood proofing by perimeter protection is usually applicable to multi-building installations or small groups of residences. These concepts are more like local protection works; therefore, they are presented as such.

42. Flood proofing investigations considered the sealing of structures. There are many devices and construction procedures available for this type of flood proofing. Appropriate measures differ with each structure and each flooding situation.

43. Twenty sample buildings were selected throughout the Basin for individual analysis. The number of samples taken are 1% (5), 11% (12), and 14% (3) of the total residential, commercial and industrial, and public units, respectively, in the 100-year flood plain. The samples were chosen in order to represent different types of construction and uses susceptible to flooding (see Table D-1). The samples for the residential and public buildings are more representative of actual types of construction and uses in the Basin. Since commercial and industrial buildings vary greatly not only in the types of structures but also their uses, these samples represent a range of structures.

44. Since a building should not be sealed beyond a level which the structure can withstand, the sample structures were reviewed for structural capacity. Their theoretical structural capacities were analyzed based on the type of construction. It was found that about 40, 75, and 100 percent of the residential, commercial and industrial, and public buildings, respectively, are able to withstand the floodwater forces and stresses resulting from the flood proofing to the 100-year level. Of these, 100, 55, and 65 percent, respectively, are found to be economically justified. Flood proofing results in 50, 70, and 30 percent reductions in total average annual damages for the sample buildings, respectively. Applied basin-wide, the annual reduction in damages would be 20, 30, and 20 percent for each category, respectively.

45. In summary this analysis showed that economically justified flood proofing measures could be provided for about 40% of all residential buildings, 40% of commercial and industrial buildings, and 65% of all public buildings located in the flood plain.

TABLE D-1
CHESTER CREEK BASIN
FLOOD PROOFING SAMPLES

| Type of Structure | Basement | Type of Foundation | First Floor Construction | 1971 Level (Feet)1/ | Level of Flood Proof-ing (Feet)1/ | Approximate Level Protection (year) |
|---|---|---|---|---|---|---|
| **Residential** | | | | | | |
| Semi-detached | Yes | Poured concrete | Brick | -2 | None 2/ | 0 |
| Row | Yes | Poured concrete | Brick | -1 | None | 0 |
| Row | Yes | Poured concrete | Brick | +3-1/2 | 0 | 60 |
| Row | Yes | Poured concrete | Brick & Stone | 0 | 0 | 90 |
| Row | Yes | Stone | | 0 | None | 0 |
| **Commercial and Industrial** | | | | | | |
| Pump station | Yes | Poured concrete | Brick | +2 | None | 0 |
| School | No | Concrete slab | Cinder block & brick | +4 | +4 | 90 |
| Retail store | No | Concrete slab | Cinder block & brick | +3-1/2 | +4 | 100 |
| Retail store | Yes | | Masonry | +2 | None | 0 |
| Manufacturing | No | Concrete slab | Masonry | +8 | +4 | 55 |
| Service | Yes | Poured concrete | Brick | +1 | None | 0 |
| Retail Store | No | Concrete clab | Brick | +3 | +5 | 220 |
| Manufacturing | Yes | Stone, poured concrete | Brick & stone | +2 | -5 | 25 |
| Auto repair | No | Concrete slab | Cinder block | +10 | +4 | 30 |
| Manufacturing | No | Concrete slab | Corrugated steel | +3 | +4 | 105 |
| Manufacturing | No | Concrete slab | Brick | +6 | +5 | 25 |
| Retail store | Yes | Concrete block, stone | Wood frame, & stone | 0 | 0 | 80 |
| **Public Facilities** | | | | | | |
| School | No | Concrete slab | Brick | +6 | +5 | 80 |
| School | No | Concrete slab | Brick | +10 | +5 | 50 |
| YMCA | Yes | Concrete slab | Brick & steel | +6 | +5 | 80 |

1/ Levels above (+) or below (-) first floor level.
2/ None indicates that no floodproofing was possible due to structural considerations

| FP1 | FLOOD PROOFING<br>CHESTER CREEK BASIN |
|---|---|

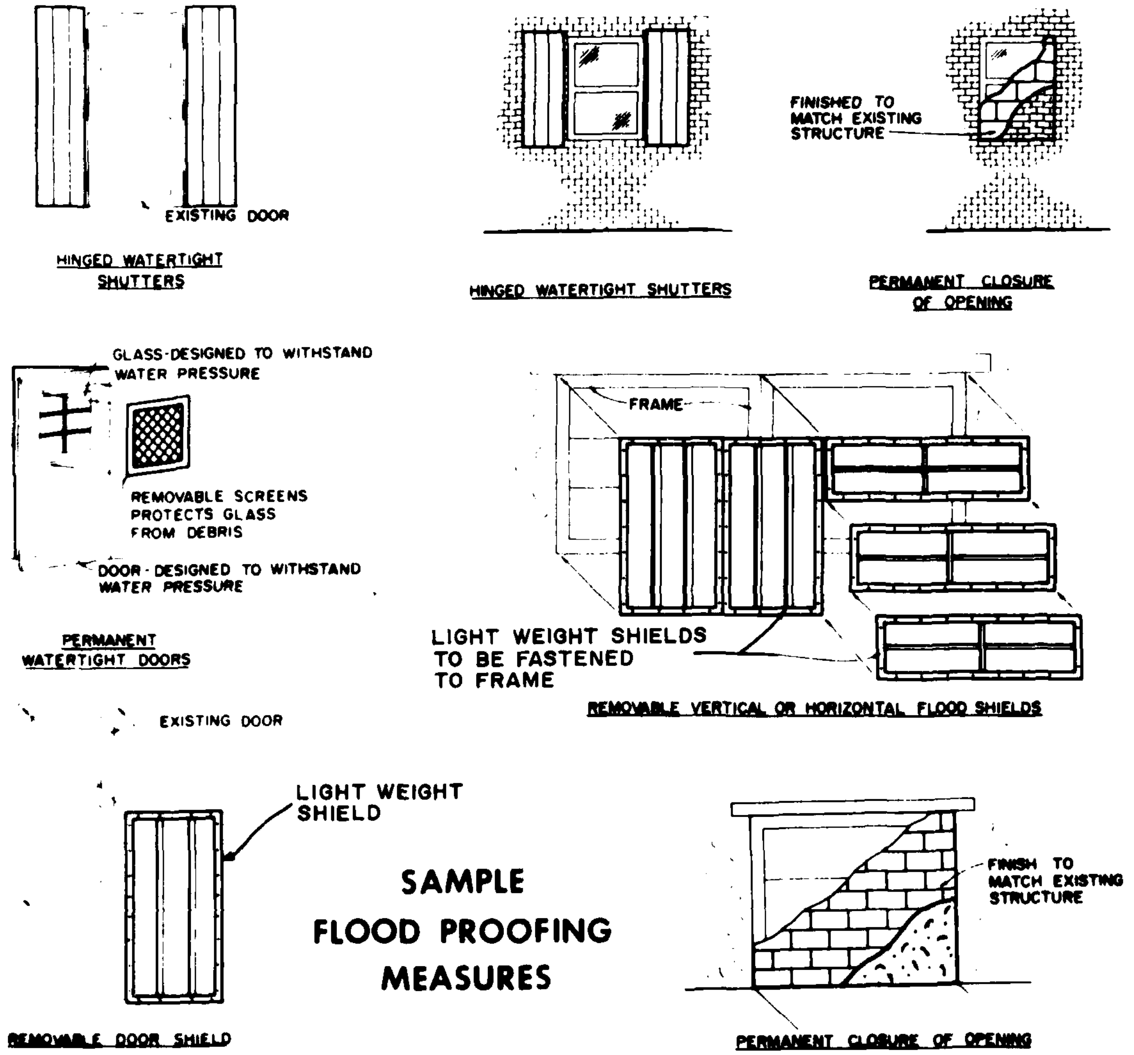
# DESCRIPTION

**PLAN** This plan involves sealing the openings of all residences, businesses, industries, and public facilities up to the highest water level the structure can withstand, and installation of sump pumps to control seepage. The sketch shows some of the various measures and devices used to flood proof buildings. The flood proofing devices would be maintained by building owners. Using samples, the plan, which requires the design and analysis of each individual building, was evaluated for the Basin as a whole. (WARNING: STRUCTURAL ADEQUACY OF BUILDINGS TO RESIST ADDITIONAL HYDROSTATIC LOADS IMPOSTED BY FLOOD PROOFING SHOULD BE FULLY ANALYZED BEFORE FLOOD PROOFING MEASURES ARE USED.

**LOCATION** All flood plains in the Chester Creek Basin

**PROJECT LIMITS** Flood plains from West Chester area to the Delaware River

**PROTECTION LIMITS** Flood plains from West Chester area to the Delaware River



| FP1 | FLOOD PROOFING<br>CHESTER CREEK BASIN |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** 25 to 225 year flood for the samples investigated

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** No effect

**DAMAGE LEVELS** Eliminates $3,485,500 of the $13,940,000 in damages

## ECONOMICS

SAMPLING: Over 20 buildings in the flood plain were analyzed, including 5 residential, 12 commercial and industrial, and 3 public buildings. Our analysis showed that economically justified flood proofing measures could be provided for about 40% of all residential buildings, 40% of all commercial and industrial buildings, and 65% of all public buildings located in the flood plain.

BENEFITS: Benefits accured by flood proofing (sealing openings) consist of structural and contents damages which would have occurred inside of the structure had it not been flood proofed. Exterior damages would contin to occur.

COSTS: Costs include; construction costs, the costs to evaluate structural adequacy of structures, and design costs.

RECREATION: No recreational facilities can be provided by project.

BENEFIT/COST RATIO: The benefit to cost ratios for the residential, commercial and industrial, and public buildings in the Basin would vary for each category from 1.0 to 3.4, from 0.1 to 9.7, and from 0.4 to 1.7, respectively.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Slight reduction in flood related problems.
- Retardation of the deterioration of some flood plain structures
- False sense of security may encourage people to stay in the building instead of evacuating.
- Continued destruction of the stream bank and flood plain environment, through erosion of banks and deposition of silts and debris.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 25% reduction in the $818,720 annual damages in the Basin.
- Reduction of restrictions to economic growth of business and taxable property located in the flood plain.

## CONCLUSIONS

This alternative can economically provide high levels of protection to some structures. However, neither Chester or Delaware Counties or individual municipalities could provide sponsorship. It was eliminated from further consideration. Delaware County is interested in pursuing floodproofing on its own.

46. FLOOD FORECASTING, WARNING, AND PREPAREDNESS PLANNING. Flood forecasting, flood warning, and preparedness planning are each individual components of an overall plan. This plan is one which does not, in itself, eliminate damages but can reduce damages and prevent the loss of life. Some forecasting and warning has existed as part of the regular program of the National Weather Service (NWS). The loss of eight lives and inundation of more than 200 motor vehicles in the 1971 flood attests to the fact that either a warning was not sufficient or a poor respond was obtained. Improvements were made since the 1971 flood. These include the installation of a flash flood warning alarm consisting of a sensor located off Old Forge Road near Glen Mills and an alarm located at the Media Court House. This system was installed in 1973. In addition, there have been improvements in communications between the County Civil Defense and NWS during storm periods. Although these improvements have not yet been tested by a major flood, it is felt that the existing arrangements are still not adequate.

47. In the Chester Creek Basin a system must be highly reliable, have adequate advance warning times, and include fairly sophisticated prepardness plans because of the following:

The "flash flood" nature of flooding in the Basin;

The history of many lives lost and inundation of readily mobile property such as cars and trucks;

The potential of severe flooding of major population centers at West Chester, Chester, Upland and Toby Farms, which have large amounts of industrial, commercial, residential, and public flood plain properties.

48. With observed times of concentration of about four to seven hours in the Basin, forecasting of the flood event becomes of prime importance so as to provide sufficient warning. The warning time needed at a site depends on location along the stream; physical topography of the area; communications; and access to and aequacy of evacuation routes.

49. The flood forecasting, warning, and preparedness plan would be as follows:

Flood forecasting should increase actual flood warning time by supplementing the warning time of a sensor gage. Preparation against flooding would begin with the flash flood watch and warning forecasts announced by NWS. The forecast system would also include precipitation gages distributed throughout the Basin and operated by private citizens. These precipitation readings will allow an interim estimate of potential flooding prior to activation of stream gages. The readings would be taken after the NWS regional forecast and prior to activation of the stream gages.

Warnings would be broadcasted over radio and television; sirens or alarms would be activated, and warnings disseminated at a community and neighborhood level of police, firemen, civil defense, and other organized emergency and disaster personnel. Disaster personnel would carry out functions according to a predetermined plan. Preventive actions would include curtailing electrical and gas service in flooded areas; providing rapid medical and evacuation assistance; protecting vital records; proper dispersing of emergency forces; and establishment of emergency housing sites.

Time allowing, individuals can take additional actions to protect property including temporary flood proofing and evacuation of some property.

50. The following assumptions were made in the analses:

Technical data developed during the Metropolitan Chester Creek Basin Study is suitable for use in developing a final plan;

Existing facilities are adequate as emergency operating centers;

Existing available rescue, traffic control and communications equipment are adequate; and

Updating and maintaining preparedness plans will become the responsibility of civil defense and other local agencies as part of their normal duties.

| FW1 | FLOOD FORECASTING, WARNING, AND PREPAREDNESS PLANNING |
|---|---|

## DESCRIPTION

**PLAN** This plan would consist of National Weather Service flood forecasts, a precipitation observer network in upstream areas, sensor gages along Chester Creek, a warning system and an emergency plan of action. Following the Weather Service's forecast of a potential flood, and confirmation through local rainfall observations; radio, television, and sirens would be used to alert flood plain occupants of the flood potential. The two sensor gages would warn of impending flood stages, and would trigger temporary evacuation, of both people and damageable property, traffic control, and other planned emergency actions.

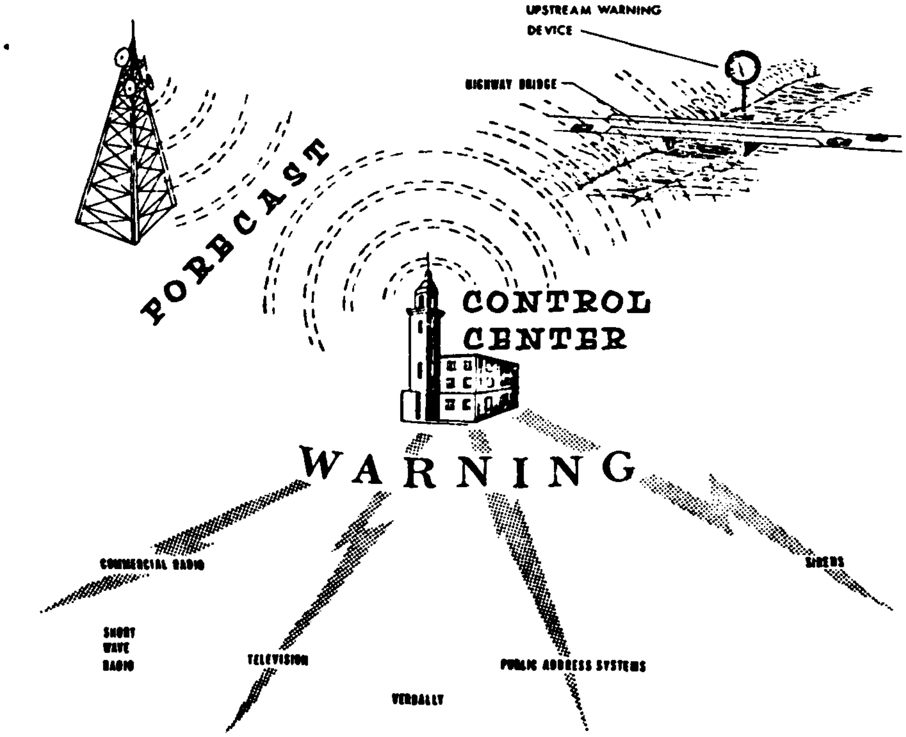
**LOCATION** Entire Chester Creek Basin

**PROJECT LIMITS** West Chester Borough to the Delaware River

**PROTECTION LIMITS** West Chester Borough to the Delaware River

**MINIMUM REQUIREMENTS FOR A TOTAL SYSTEM**

- community education
- early recognition of impending floods
- issuance and dissemination of warnings
- evacuation of threatened areas
- rescue and other emergency action
- allocation of responsibility for action
- plan practice



| FW1 | FLOOD FORECASTING, WARNING, AND PREPAREDNESS PLANNING |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Provides time for action to reduce damages

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** No effect

**DAMAGE LEVELS** Eliminates $1,394,000 of the $13,940,000 in damages

## ECONOMICS

| | |
|---|---|
| PROJECT COST (TOTAL) | $86,700 |
| construction | 86,700 |
| lands and relocation | 0 |
| recreation | * |
| AVERAGE ANNUAL COSTS (TOTAL) | $20,600 |
| interest and amortization | 5,600 |
| operation and maintenance | 15,000 |
| AVERAGE ANNUAL BENEFITS (TOTAL) | $81,900 |
| flood control | 81,900 |
| recreation | * |
| BENEFIT / COST RATIO | |
| FLOOD CONTROL ONLY | 3.9 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreational facilities can not be provided by project.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems with health and safety.
- An increase in psychological stresses from the threat of floods due to false warnings.
- Continued destruction of stream bank and flood plain environment through erosion of banks and deposition of silt and debris.
- Significant reduction in dangers to life and health caused by floods.

## REGIONAL / ECONOMIC EFFECTS (major)

- Reduction in damages due to ability to move contents (potential 12% reduction in annual damages)
- Annual administration costs for updating, maintaining, and coordinating the system.
- A decrease in the tax base, employment and population caused by restriction of economic growth in flood plain lands.

## CONCLUSIONS

This alternative can reduce flood problems; is economically justified; and has only minor adverse adverse effects. However, neither Chester or Delaware Counties or any municipalities could provide sponsorship. It was eliminated from consideration. Delaware County is interested in pursuing this plan on its own

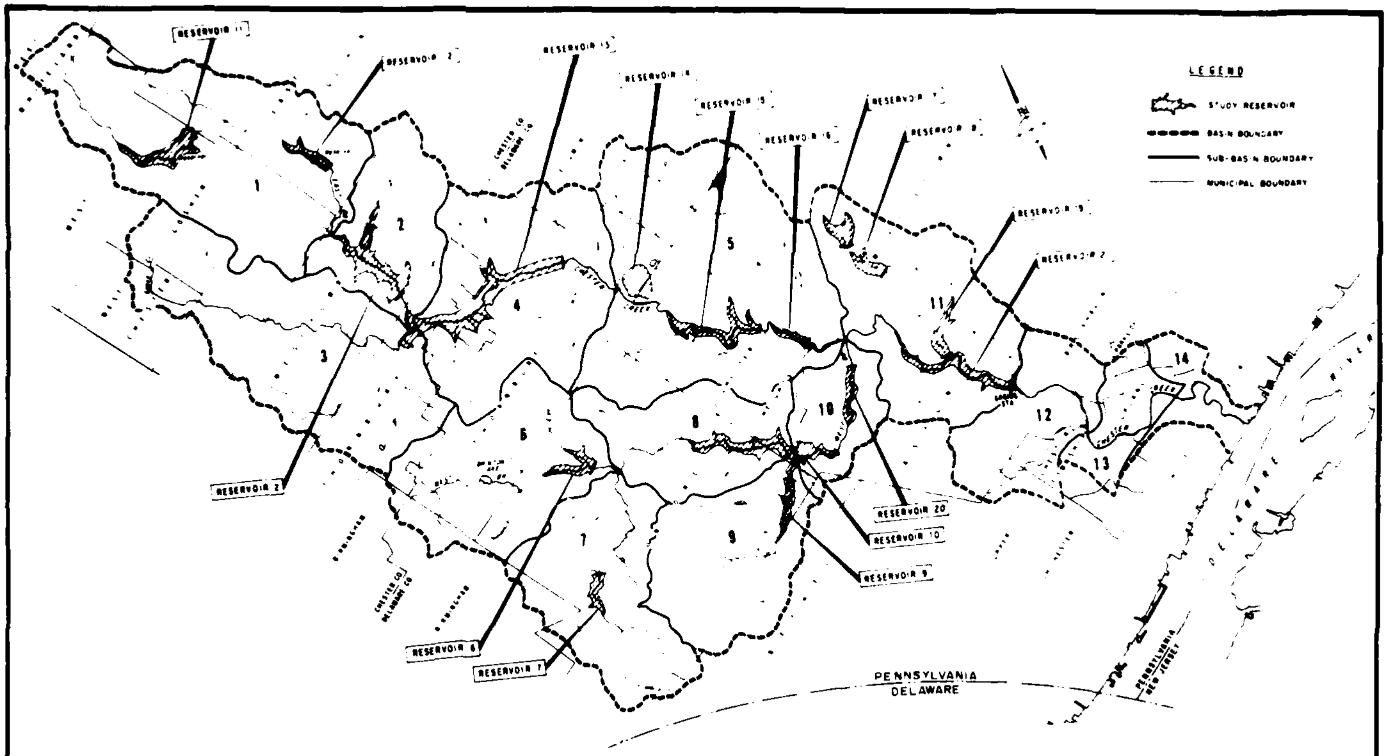
51. RESERVOIR STORAGE. The feasibility of reservoir storage of floodwaters was investigated for the Basin. Multi-purpose potential, including flood control, water supply, and recreation was considered. It became immediately obvious that, water supply could only be developed at the expense of flood control due to limited storage available at sites, cost of additional land, and low levels of flood protection which could be provided.

52. Since floodwater and flood plain management is the primary purpose of this study, water supply potential was assumed to be a secondary consideration. Because of the constraints of developing reservoirs, single purpose dry reservoir concepts were emphasized. Recreation potential was estimated only for the economically attractive dry reservoirs. Estimates were conducted in sufficient detail to indicate whether recreation should be included in any further consideration of reservoirs.

53. Twenty-one potential storage sites were identified during Cycle 1 from a study of topographic maps; aerial photos; a U.S. Soil Conservation Service reconnaissance study; Appendix D of the Delaware Basin Report (House Document No. 522); and field reconnaissance. Initial screening was conducted during the field reconnaissance. Sites were eliminated because of constraints to project development. Five of the twenty-one sites were eliminated. The remaining sixteen are shown on Plate D-1..

54. Three additional screenings were conducted during Cycle 2. The first screening was based on initial hydrologic analyses. Reservoirs were sized to store the volume of runoff from a 50-year storm, if possible. Beyond this, physical constraints such as large costs for numerous building relocations often limited the volume that could practically and economically be stored. The results of the initial hydrology analysis is presented in Table D- 2. It is readily apparent that reservoirs 11, 12 and 15 through 21 individually have little or no effect on peak flows and were screened out from further consideration. Also, it was after this work that the decision was made to eliminate any further consideration of water supply, due to limited storage capacity.

55. The second screening was based on approximate project costs and the damages reduced by the reservoirs. As a result of this screening, four more plans were eliminated. The economics of these plans are summarized in Table D- 3. Only reservoir plans R6, R10 and R13 were investigated at the complete Cycle 2 level of detail. These are the only plans presented fully in this section. Table D- 4 is included for a more complete presentation of hydraulic performance. The effects of future urbanization are presented for the year 2020 for comparison purposes.




NOTE:
ONLY RESERVOIR SITES WHICH WERE NOT SCREENED OUT DURING PRELIMINARY ANALYSIS ARE SHOWN

SCALE IN MILES

CHESTER CREEK BASIN, PENNSYLVANIA

LOCATION OF RESERVOIR PLANS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE D-1

TABLE D-2
REGULATED PEAK FLOWS
RESERVOIR PLANS
(Second Screening)

| Reservoir Location | At the USGS Gage 10-Year | 25-Year | 100-Year | Confluence with the West Br 10-Year | 25-Year | 100-Year |
|---|---|---|---|---|---|---|
| No Reservoir | 8,090 | 11,900 | 30,300 | 4,760 | 7,010 | 11,900 |
| 2 | 170 | 250 | 430 | 530 | 790 | 1,330 |
| 6 | 890 | 1,310 | 2,230 | 0 | 0 | 0 |
| 7 | 430 | 630 | 1,080 | 0 | 0 | 0 |
| 9 | 510 | 640 | 0 | 0 | 0 | 0 |
| 10 | 2,950 | 4,330 | 7,090 | 0 | 0 | 0 |
| 11 | 0 | 0 | 0 | 50 | 80 | 130 |
| 12 | 0 | 0 | 0 | 180 | 260 | 440 |
| 13 | 1,130 | 1,650 | 2,880 | 1,380 | 950 | 240 |
| 15 | 1,510 | 580 | 390 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 70 | 10 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 |

TABLE D-3
PRELIMINARY ECONOMICS
RESERVOIR PLANS
(Third Screening)

| Reservoir | Storage (ac-ft) | Average Annual Cost 1/ ($000) | Average Annual Benefit ($000) 2/ 3/ | Benefit/Cost Ratio |
|---|---|---|---|---|
| 2 | 4,275 | 145 | 25 | .17 |
| 7 | 525 | 132 | 49 | .37 |
| 9 | 410 | 104 | 27 | .26 |
| 15 | 960 | 91 | 57 | .62 |

1/ Annual cost computed using preliminary 1974 cost estimates, 50-year project life, and 6-1/8 percent discount rate. No O&M cost included.
2/ Inundation only; damages July 1974 dollars and 1970 land use in the Basin. No urbanization included.
3/ Total average annual damages are $441,000.

TABLE D-4
HYDRAULIC EFFECTS AT SELECTED LOCATIONS
RESERVOIR ALTERNATIVES R6, R10, AND R13

| Selected Index Station and Location 1/ | Existing Basin Condition: 50-Year Event Stage | Existing: 50-Year Event Δ Stage 2/ | Existing: 100-Year Event Stage | Existing: 100-Year Event Δ Stage 2/ | Existing: SPF Event Stage | Existing: SPF Event Δ Stage 2/ | Future Basin Conditions (2020): 50-Year Event Stage | Future: 50-Year Event Δ Stage 2/ | Future: 100-Year Event Stage | Future: 100-Year Event Δ Stage 2/ | Future: SPF Event Stage | Future: SPF Event Δ Stage 2/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R6 | | | | | | | | | | | | |
| 1 (Fifth Street) | 11.5 | 2.1 | 16.8 | 0.8 | 21.3 | 1.2 | 13.6 | 3.6 | 17.6 | 1.4 | 21.6 | 1.4 |
| 4 (Kerlin St.) | 22.0 | 0.8 | 25.6 | 0.9 | 32.0 | 1.7 | 23.4 | 2.7 | 26.3 | 2.5 | 33.3 | 2.4 |
| 5 (Toby Farms) | 24.0 | 1.0 | 27.8 | 1.0 | 34.3 | 1.5 | 26.0 | 2.3 | 28.5 | 2.5 | 35.6 | 2.1 |
| 9 (Lenni) | 102.4 | 0.6 | 104.0 | 0.5 | 107.3 | 0.7 | 103.0 | 1.3 | 104.4 | 1.3 | 107.7 | 1.5 |
| R10 | | | | | | | | | | | | |
| 1 (Fifth St.) | 13.6 | 4.8 | 13.6 | 4.0 | 21.9 | 0.6 | 9.2 | 8.0 | 14.5 | 4.5 | 21.8 | 1.2 |
| 4 (Kerlin St.) | 19.2 | 3.6 | 23.4 | 3.1 | 33.7 | 0.0 | 20.0 | 6.1 | 23.7 | 5.1 | 33.7 | 2.0 |
| 5 (Toby Farms) | 22.7 | 3.2 | 25.9 | 2.9 | 35.8 | 0.0 | 23.4 | 4.9 | 26.2 | 4.8 | 36.4 | 1.8 |
| 9 (Lenni) | 100.7 | 2.3 | 103.0 | 1.5 | 108.0 | 0.0 | 101.3 | 3.0 | 103.4 | 2.3 | 108.2 | 1.0 |
| R13 | | | | | | | | | | | | |
| 1 (Fifth St.) | 10.9 | 2.7 | 16.5 | 1.1 | 21.7 | 0.8 | 14.5 | 2.7 | 18.0 | 1.0 | 22.6 | 0.4 |
| 4 (Kerlin St.) | 21.6 | 1.2 | 25.3 | 1.2 | 32.7 | 1.0 | 23.7 | 2.4 | 26.9 | 1.9 | 34.8 | 0.9 |
| 5 (Toby Farms) | 24.6 | 1.3 | 27.6 | 1.2 | 35.0 | 0.8 | 26.2 | 2.1 | 29.0 | 2.0 | 37.2 | 0.5 |
| 9 (Lenni) | 102.2 | 0.8 | 103.9 | 0.6 | 107.7 | 0.3 | 103.4 | 0.9 | 104.7 | 1.0 | 108.3 | 0.9 |

1/ See Plate for index station location.
2/ Stage without the reservoir minus stage with the reservoir.

| R6, R10, R13 | DRY RESERVOIRS |
|---|---|

## DESCRIPTION

**PLAN** Plan R6 involves the construction of a 59 foot high earth and rock dam on W. Branch Chester Creek with a 131 acre dry reservoir. One-half mile of road, utilities, and 5 buildings would be relocated. Plan R10 includes a 60 foot high dam on the West Branch with a 487 acre dry reservoir. Over 2 miles of road, utilities, and 16 buildings would be relocated. Plan R13 includes a 25 foot high dam on Chester Creek with a 253 acre dry reservoir. Over 2 miles of roads; 2 miles of railroad; utilities; and 4 buildings would be relocated. Reservoir areas, when dry, could be used for recreation. Maintenance would be a local responsibility.

**LOCATION** The reservoirs would be located in Aston, Chester Heights, Concord, and Thornbury in Delaware County and Thornbury in Chester County.

**PROJECT LIMITS** Areas required for reservoir impoundments

**PROTECTION LIMITS** Dam site to the Delaware River

SITE R6. Over 30 to 40 percent of the reservoir area is heavily wooded. Five homes appear to have access during flooding. Homes are continuously being built in the vicinity of the reservoir. Land prices are above normal. The dam would be located about 1/4 mile above Baltimore Pike (U.S. Route 1).

SITE R10. The dam would be located about 1/2 mile above Birney Highway. The Penn Central Railroad located in the site was to be abandoned but was purchased by the Regional Transit Authority (SEPTA) during the course of the study. Road relocation of Highway 261 may not be necessary since there is sufficient access from all sides of this reservoir. The road can be left and closed during flooding. The homes on the north side of Smithbridge Road could require special access during flooding. This would be provided through a pipeline right-of-way. The area south of Smithbridge Road is partially in pasture but is mainly heavily wooded. There is a wildlife refuge just north of Ivy Mill Road located within the northern reach of the reservoir. There would be some road relocation for a few homes just north Ivy Mill Road that would be blocked during flooding. Three buildings are located in Chester Heights where Highway 261 runs north across the West Branch; two homes and a barn. There is also a new, small sewage treatment unit located in or near the reservoir northeast of this intersection.

SITE R13. The dam would be located about 1 mile above Hillis Road. Several roads and 2 miles of active Penn Central Railroad would be inundated. This area is fairly open with little flood plain development. A portion of Cheyney State College land would be inundated.

| R6, R10, R13 | DRY RESERVOIR |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Varies at different locations

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** See Table

**DAMAGE LEVELS** R6 - Eliminates $2,435,000 of $13,083,000 in damages;
R10 - Eliminates $7,962,000; and
R13 - Eliminates $3,165,000.

## ECONOMICS

| | R6 | R10 | R13 |
|---|---|---|---|
| **PROJECT COST (TOTAL)** | $3,162,000 | $8,642,000 | $15,149,000 |
| construction | 1,710,000 | 3,077,000 | 4,520,000 |
| lands and relocation | 1,290,000 | 5,013,000 | 10,260,000 |
| recreation | 162,000 | 552,000 | 369,000 |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 235,000 | $ 588,000 | $ 1,008,000 |
| interest and amortization | 205,000 | 558,000 | 978,000 |
| operation and maintenance | 30,000 | 30,000 | 30,000 |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 448,000 | $1,263,000 | $ 720,000 |
| flood control | 195,000 | 419,000 | 188,000 |
| recreation | 253,000* | 844,000* | 532,000* |
| **BENEFIT / COST RATIO** | | | |
| FLOOD CONTROL ONLY | 0.87 | 0.76 | 0.19 |
| FLOOD CONTROL & RECREATION | 1.9* | 2.1* | 0.71* |

* Recreation benefits result from complete utilization of project lands. However, they can not be used to justify the flood control project.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Slight reduction of flood related problems.
- Slight reduction in the deterioration of existing flood plain structures (flood plain fringe areas only).
- Increase opportunity for recreation, conservation and natural development.
- Alteration of the natural environment at the reservoir site and at the sites used to supply materials for construction.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 28%, 60%, and 27% reduction (for R6, R10, and R13, respectively) of the $696,000 in annual damages in areas downstream of the reservoir.
- Annual maintenance costs for the reservoir.
- Slight improvement in the economic growth of business and taxable property located in the areas protected by the reservoir.

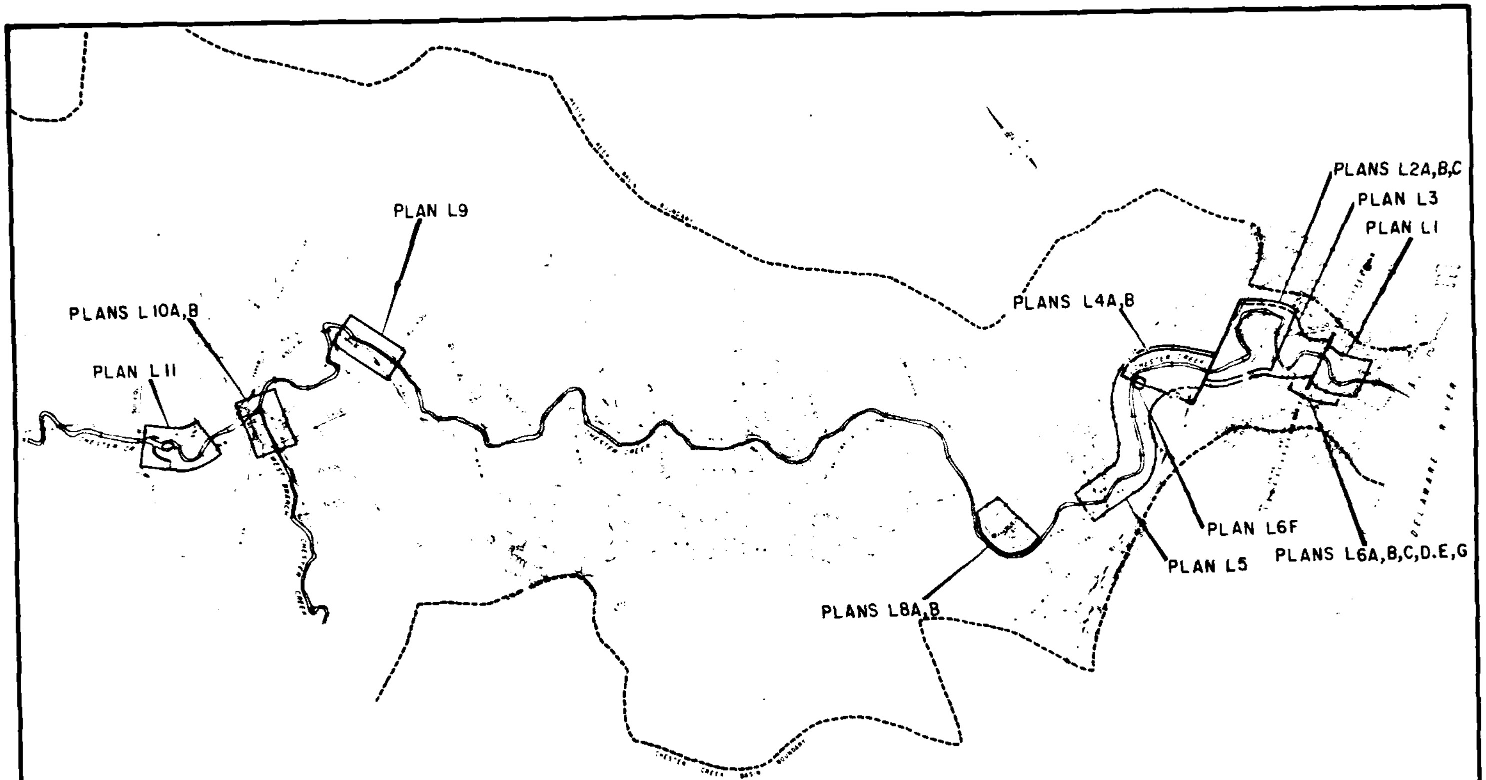
## CONCLUSIONS

These alternatives can provide some protection. They can not be economically justified as flood control projects and have major adverse environmental effects. They were eliminated from further consideration.

## LOCAL IMPROVEMENT PLANS

56. All possible types of local structural and non-structural solutions were conisdered at each major damage area. Many were eliminated as technically infeasible or obviously too costly. These decisions were made based on engineering judgement and experience or with reconnaissance-level analyses. These solutions are not presented in detail in this report. Those plans which were selected as the best plans for each major damage area in the lower Basin are listed below and the locations of the damage sub-reaches which they protect are shown on Plate D-2.

| ALPHA-NUMERIC | ALTERNATIVE PLAN IDENTIFICATION | LOCATION |
|---|---|---|
| L1 | Levees & Floodwalls | City of Chester |
| L2 | Levees & Floodwalls | City of Chester Schools |
| L3 | Levees, Floodwalls & Channel Realignment | City of Chester (Schools & YMCA) |
| L4 | Levees & Floodwalls | Crozer Park Gardens |
| L5 | Bridge Modification | City of Chester & Borough of Upland |
| L6A, L6B L6C, L6D | Bridge Modification | City of Chester |
| L6E | Channel Clearance | City of Chester |
| L6F | Channel Clearance | City of Chester & Borough of Upland |
| L7A, L7B | Channel Excavation | City of Chester, Upland Boro, Chester Twp, Brookhaven Boro, Aston Twp |
| L7C, L7D | Channel Excavation | City of Chester, Upland Boro, Chester Twp |
| L8A, L8B | Levee | Chester Twp (Toby Farms) |
| L9 | Levee | Aston Twp |
| L10A, L10B | Levees, Floodwalls, & Bridge Modifications | Aston Twp & Middletown Twp (Lenni) |
| L11 | Levees, Floodwalls, Bridge & Channel Modifications | Aston Twp, Middletown Twp & Chester Heights Boro (Aston Mills) |




NOTE PLANS NOT SHOWN

- PLANS L7A, L7B - CHANNEL DREDGING, STA 9+00 TO STA. 285+00.
- PLANS L7C, L7D - CHANNEL DREDGING, STA. 50+00 TO STA. 185+00

SCALE IN FEET

CHESTER CREEK BASIN, PENNSYLVANIA

LOCATION OF

LOCAL IMPROVEMENT PLANS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

PLATE D-2

| L1 | LEVEES AND FLOODWALLS<br>CHESTER CENTRAL BUSINESS DISTRICT |
|---|---|

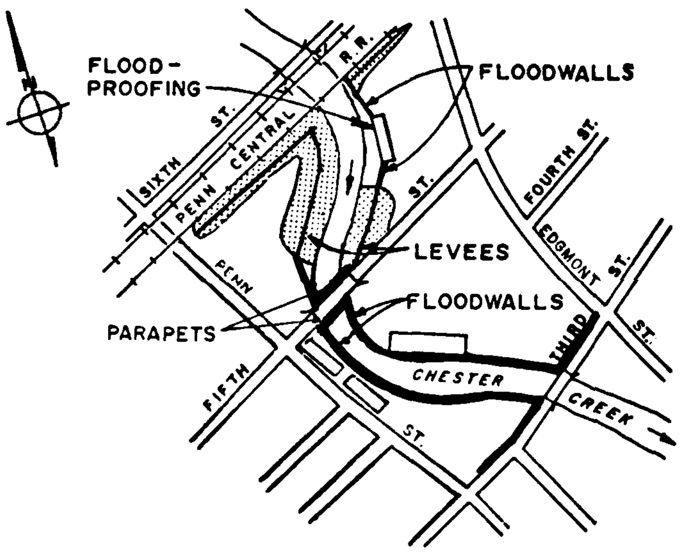
## DESCRIPTION

**PLAN** This plan consists of the construction of 1750 feet of earth levees and 2050 feet of concrete floodwalls along Chester Creek. Floodwalls are constructed where space is limited so as to preserve existing buildings. A 5 foot high wall would be built on both sides of the 5th Street bridge to prevent overtopping. A building on the left bank would be flood proofed. This work would consist of strengthening the walls adjoining the Creek and sealing openings. The floodwall will tie into the strengthened walls. The levees would be protected against erosion by provision of a riprap (rock) lining.

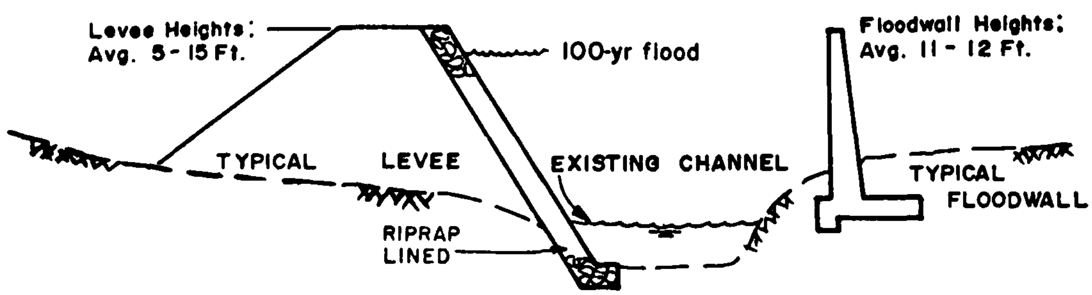
**LOCATION** City of Chester

**PROJECT LIMITS** 3rd Street to the Penn Central Railroad bridge

**PROTECTION LIMITS** 3rd Street to the Penn Central Railroad bridge




The floodwalls would be extended inland paralleling the 3rd Street Bridge's upstream face. A building on the left bank would be flood proofed with floodwalls tied into the buildings to eliminate backing up of flows from downstream. Potential problems would be where floodwalls are tied into older buildings and access to parking lots and loading docks. Clearance for the facilities in the vicinity of the railroad bridge appear adequate. Interior drainage facilities would be needed to drain the area. However, an interior drainage plan was not developed due to the plan not being economically justified.



| L1 | LEVEES AND FLOODWALLS<br>CHESTER CENTRAL BUSINESS DISTRICT |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** 100 year flood

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Protects against the 100 year flood level which would be up to 12 feet above the bank

**DAMAGE LEVELS** Eliminates all of the $1,092,000 in damages

## ECONOMICS

| | |
|---|---|
| **PROJECT COST (TOTAL)** | $1,563,000 |
| construction | 1,533,000 |
| lands and relocation | 30,000 |
| recreation | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 100,900 |
| interest and amortization | 100,900 |
| operation and maintenance | ** |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 16,800 |
| flood control | 16,800 |
| recreation | * |
| **BENEFIT / COST RATIO** | |
| FLOOD CONTROL ONLY | 0.17 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project

** Not estimated due to obvious economic infeasibility

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems for those people whose buildings are protected
- Reduction of psychological stresses from the threat of floods.
- Retardation of the deterioration of some flood plain structures.
- Alteration of the natural environment at the project area and at sites used to supply materials for construction.
- Visual obstruction and reduced access to Creek.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 50% reduction of the $34,000 in annual damages in the area protected.
- Elimination of restrictions to economic growth in the area protected with potential for employment, increased profits, and a more stable tax base.

## CONCLUSIONS

This alternative can provide a high level of protection. However, it is not economically justified and has significant adverse environmental and social effects. It was eliminated from further consideration.

| L2 | LEVEES AND FLOODWALLS<br>CITY OF CHESTER SCHOOLS |
|---|---|

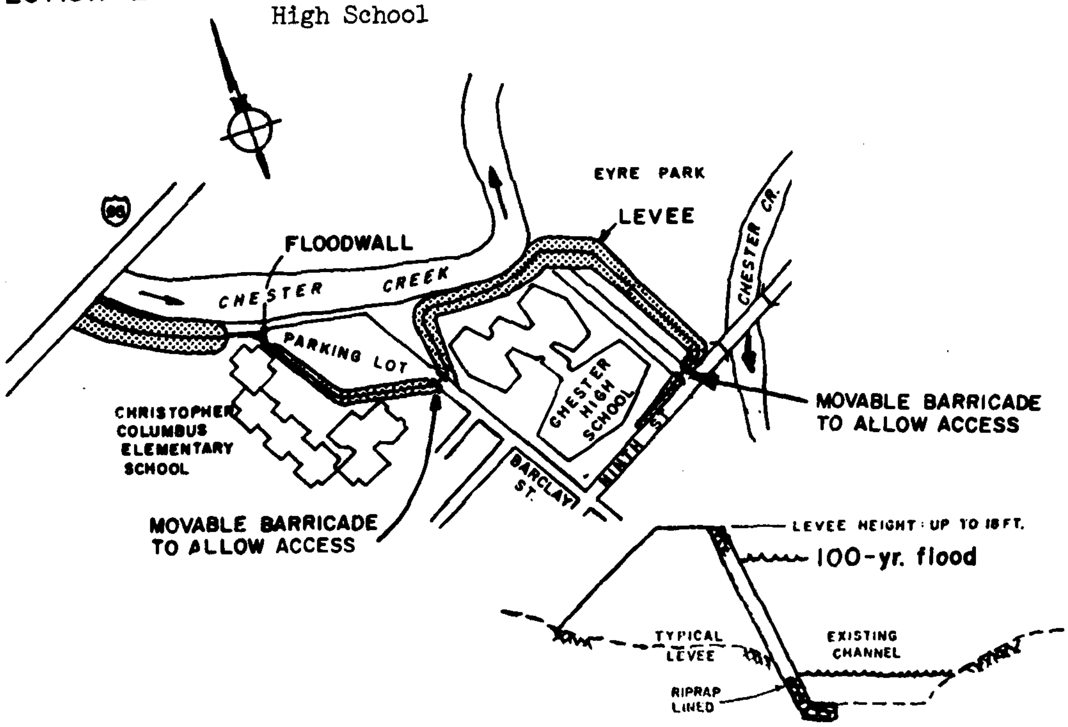
# DESCRIPTION

**PLAN** This plan provides protection to two schools by construction of 2400 feet of earth levee and 150 feet of concrete floodwall. This plan was aligned on higher ground to minimize construction costs. Movable barricades will be placed across access points during flooding. Levees and floodwalls to provide 50 year protection were also considered. These were also not economically justified. In addition providing protection at a level less than 100 year was considered unacceptable for school buildings with children and young adults.

**LOCATION** City of Chester

**PROJECT LIMITS** 9th Street to Interstate 95

**PROTECTION LIMITS** Christopher Columbus Elementary School and Chester High School




This plan denies access to the school's parking lot. The access problem can be solved by locating the levees and floodwalls adjacent to the Creek. The cost of such a plan would be in excess of $1 million with no appreciable increase in benefits. Such a plan would abyiously not be economically justified. Potential problems may stem from the large amount of foot traffic in the school grounds during construction and safety to children. Interior drainage facilities would be needed to drain the area. However, an interior drainage plan was not developed due to the plan not being economically justified. (This scheme approximates the flood protection facilities proposed in a land use plan developed for the School District by a consultant.)

| L2 | LEVEES AND FLOODWALLS<br>CITY OF CHESTER SCHOOLS |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** 100 year flood

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Protects against the 100 year flood level which would be up to 15 feet above the bank

**DAMAGE LEVELS** Eliminates all of the $1,144,000 in damages

## ECONOMICS

| | |
|---|---|
| **PROJECT COST (TOTAL)** | $641,000 |
| construction | 615,000 |
| lands and relocation | 26,000 |
| recreation | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 41,400 |
| interest and amortization | 41,400 |
| operation and maintenance | ** |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 16,600 |
| flood control | 16,600 |
| recreation | * |
| **BENEFIT / COST RATIO** | |
| FLOOD CONTROL ONLY | 0.40 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project
** Not estimated due to obvious economic infeasibility

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems to School District and parents.
- Reduction of psychological stresses from the threat of floods to large population.
- Alteration to the natural environment at the project area and at sites used to supply materials for construction.
- Visual obstruction and reduced access to Creek.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 53% reduction of the $31,000 in annual damages to the School District.
- Flimination of flood plain zoning restrictions to the expansion of the Schools.

## CONCLUSIONS

This alternative can provide a high level of protection. However, it is not economically justified and has significant adverse environmental and social effects. It was eliminated from further consideration.

| L3 | LEVEES, FLOODWALLS, AND CHANNEL REALIGNMENT<br>CITY OF CHESTER |
|---|---|

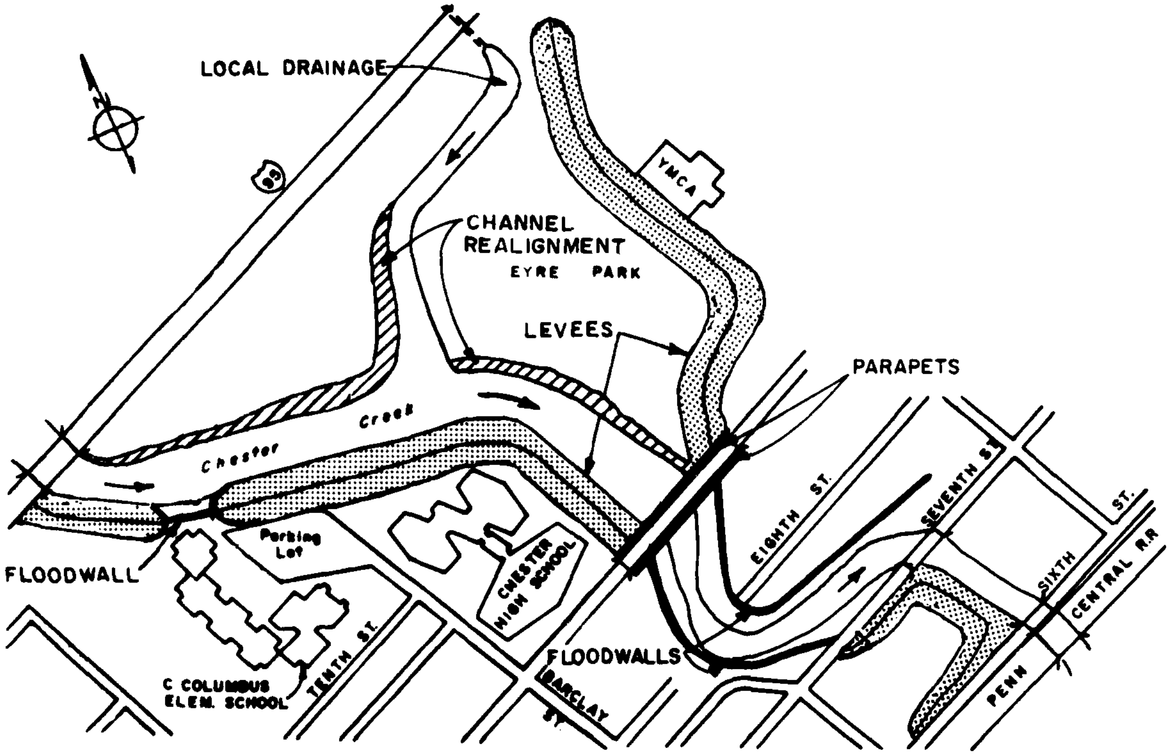
# DESCRIPTION

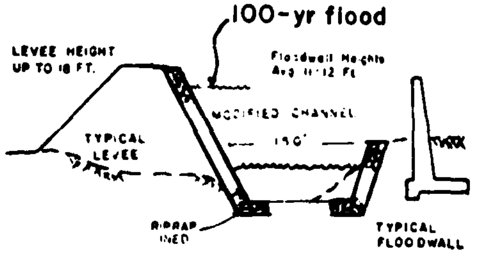
**PLAN** This plan includes the construction of 4500 feet of earth levee, 1900 feet of concrete floodwall, 1900 feet of channel realignment. A wall would be built on both sides of the 9th Street bridge to prevent overtopping. To preserve existing buildings, floodwalls would be constructed where space is limited. To existing channel would be filled in except near Interstate 95 where it would be used to carry local storm water drainage. New roads would provide access to the WMCA. Levees and stream banks would be lined with riprap (rock) to prevent erosion.

**LOCATION** City of Chester

**PROJECT LIMITS** 6th Street to Interstate 95

**PROTECTION LIMITS** Christopher Columbus Elementary School, Chester High School, YMCA and other properties between 6th Street and I-95




Interior drainage facilities would be needed to drain these areas. However, an interior drainage plan was not developed dum to plan not being economically justified.

| L3 | LEVEES, FLOODWALLS, AND CHANNEL REALIGNMENT<br>CITY OF CHESTER |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** 100 year flood

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Protects against the 100 year flood level which would be up to 15 feet above the bank

**DAMAGE LEVELS** Eliminates all of the $4,038,000 in damages

## ECONOMICS

| | |
|---|---|
| **PROJECT COST (TOTAL)** | $4,374,000 |
| construction | 4,289,000 |
| lands and relocation | 85,000 |
| recreation | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 282,300 |
| interest and amortization | 282,300 |
| operation and maintenance | ** |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 56,600 |
| flood control | 56,600 |
| recreation | * |
| **BENEFIT / COST RATIO** | |
| FLOOD CONTROL ONLY | 0.20 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreational facilities can not be provided by project.
** Not estimated due to obvious economic infeasibility.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems to a large portion of the City of Chester.
- Reduction of psychological stresses from the threat of floods.
- Retardation of the deterioration of some flood plain structures.
- Alteration of the natural environment at the project area and at sites used to supply materials for construction.
- Visual obstruction and reduced access to the Creek.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 52% reduction of the $109,000 in annual damages in the area protected by this alternative.
- Elimination of restrictions to economic growth in the area with potential for employment, increased profits and a more stable tax base.

## CONCLUSIONS

This alternative can provide a high level of protection. However, it is not economically justified and has significant adverse environmental and social effects. It was eliminated from further consideration.

| L4 | LEVEES AND FLOODWALLS<br>CROZER PARK GARDENS |
|---|---|

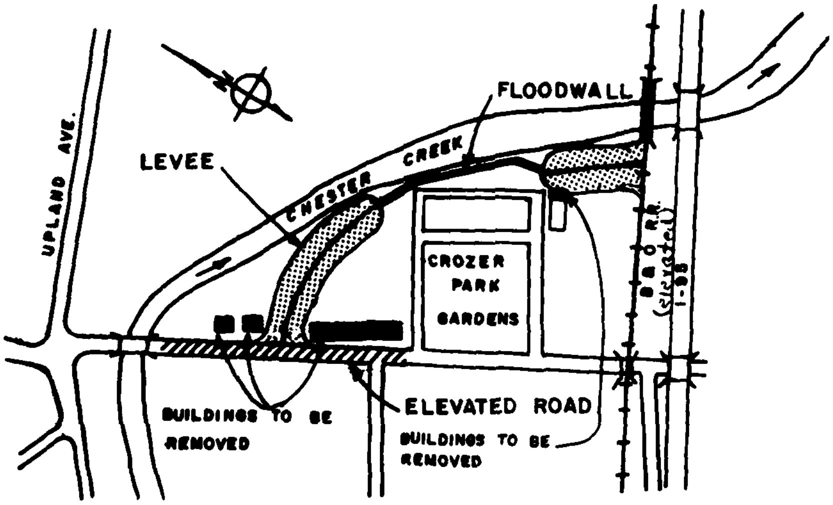
## DESCRIPTION

**PLAN** This plan protects 80 homes, with the construction of 750 feet of earth levee, 650 feet of concrete floodwall, and raising a portion of Kerlin Street. The road embankment at Kerlin Street will serve as a levee. One business and 22 homes would be relocated. The levees and road embankments would be lined with riprap (rock) to prevent erosion. A plan to provide a lower level of protection (50 year) was also considered. This was also not economically justified. In addition, providing only 50 year protection to a dense residential area may have ultimately proved unacceptable.

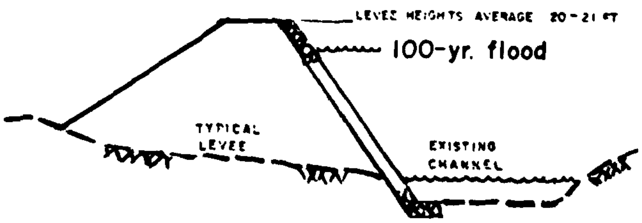
**LOCATION** City of Chester

**PROJECT LIMITS** B & O Railroad bridge to Kerlin Street

**PROTECTION LIMITS** Crozer Park Garden homes and the permanently evacuated residential and commercial units along Kerlin Street.




Raising the Kerlin Street Bridge is necessary to eliminate overflow at a low spot on Kerlin Street. Interior drainage facilities would be needed to drain the area. However, an interior drainage plan was not developed due to the plan not being economically justified.



| L4 | LEVEES AND FLOODWALLS<br>CROZER PARK GARDENS |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** 100 year flood

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Protects against the 100 year flood level which would be 18 feet abo _ the bank

**DAMAGE LEVELS** Eliminates all of the $708,000 in damages

## ECONOMICS

| | |
|---|---|
| **PROJECT COST (TOTAL)** | $1,924,000 |
| construction | 1,390,000 |
| lands and relocation | 534,000 |
| recreation | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 124,200 |
| interest and amortization | 124,200 |
| operation and maintenance | ** |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 38,000 |
| flood control | 38,000 |
| recreation | * |
| **BENEFIT / COST RATIO** | |
| FLOOD CONTROL ONLY | 0.31 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project.
** Not estimated due to obvious economic infeasibility.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems, and stresses from threat of floods
- Relocation of a significant portion of area due to construction of plan.
- Retardation of the deterioration of existing flood plain structures.
- Alteration to the natural environment at the project area and at sites used to supply materials for construction.
- Visual obstruction and reduced access to the Creek.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 71% reduction of the $53,000 in annual flood damages in the area protected by this alternative.
- Elimination of restrictions to economic growth in taxable property located in the area protected by this alternative.

## CONCLUSIONS

This alternative can provide a high level of protection. However, it is not economically justified and has significant adverse environmental and social effects. It was eliminated from further consideration.

| L5 | LEVEES, FLOODWALLS, AND CHANNEL REALIGNMENT<br>CROZER PARK GARDENS AND UPLAND |
|---|---|

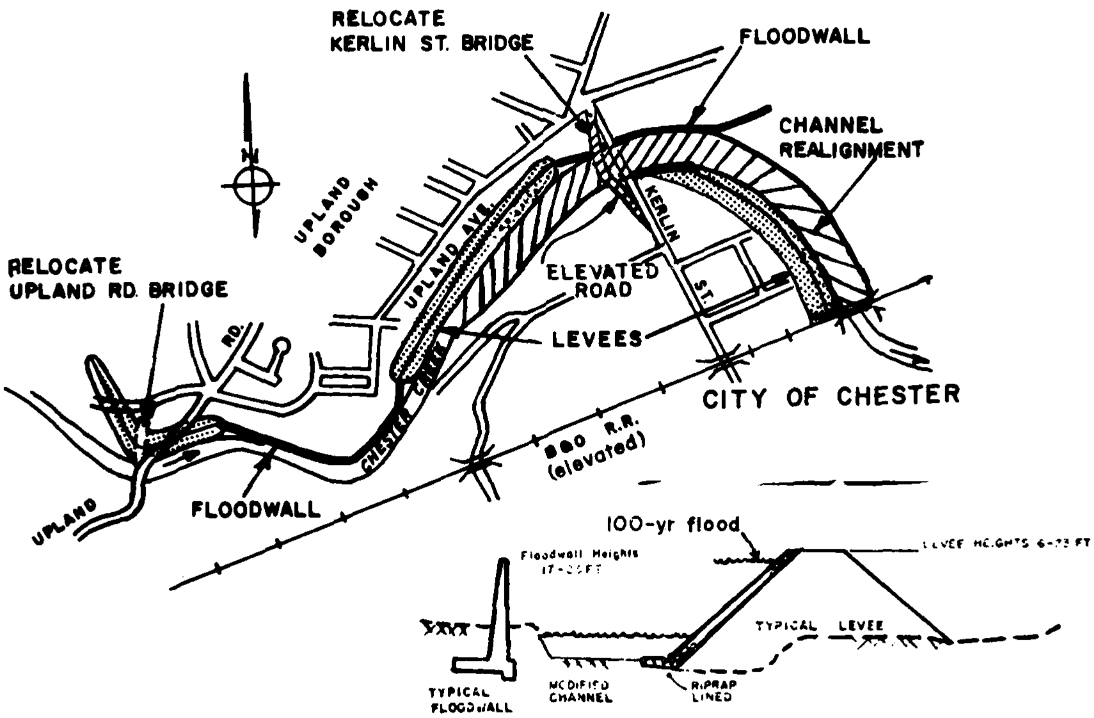
# DESCRIPTION

**PLAN** The plan provides protection through construction of 3800 feet of earth levee, 2600 feet of concrete floodwall, and 3000 feet of channel realignment. Both the Kerlin Street and Upland Road bridges would be replaced with larger capacity bridges and their approaches raised. Fourteen buildings would be relocated. The channel alignment would consist of a 170 foot bottom width channel. The levees and stream banks would be protected against erosion by provision of a riprap (rock) lining.

**LOCATION** City of Chester, and Borough of Upland

**PROJECT LIMITS** B & O Railroad bridge to upstream of Upland Road

**PROTECTION LIMITS** B & O Railroad bridge to Upland Road




Chester Creek is realigned to the south in the vicinity of the Kerlin Street to allow for levee construction on the north bank and to allow the Kerlin Street Bridge to tie into the raised roadway. The realignment of the Creek would take land from a City of Chester Park (Crozer Park). Interior drainage facilities would be needed to drain the area. However, an interior drainage plan was not developed due to the plan not being economically justified.

| L5 | LEVEES, FLOODWALLS, AND CHANNEL REALIGNMENT<br>CROZER PARK GARDENS AND UPLAND |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** 100 year level

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Protects against the 100 year flood level which would be up to 21 feet above the bank

**DAMAGE LEVELS** Eliminates all of the $2,898,000 in damages

## ECONOMICS

| | |
|---|---|
| PROJECT COST (TOTAL) | $7,636,000 |
| construction | 6,915,000 |
| lands and relocation | 721,000 |
| recreation | * |
| AVERAGE ANNUAL COSTS (TOTAL) | $ 492,900 |
| interest and amortization | 492,900 |
| operation and maintenance | ** |
| AVERAGE ANNUAL BENEFITS (TOTAL) | $ 110,100 |
| flood control | 110,100 |
| recreation | * |
| BENEFIT/COST RATIO | |
| FLOOD CONTROL ONLY | 0.22 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project

** Not estimated due to obvious economic infeasibility

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

·Reduction of flood related problems for the people whose buildings are protected.
·Reduction of psychological stresses from the threat of floods.
·Retardation of the deterioration of some flood plain structures.
·Alteration to the natural environment at the project area and at sites used to supply materials for construction.
·Visual obstruction and reduced access to Creek.

## REGIONAL / ECONOMIC EFFECTS (major)

·A 64% reduction of the $172,000 in annual damages in the area protected.
·Elimination of restrictions to economic growth in the area protected with potential for employment, increased profits, and a more stable tax base.

## CONCLUSIONS

This alternative can provide a high level of protection. However, it is not economically justified and has significant adverse environmental and social effects. It was eliminated from further consideration.

| L6A and L6B | BRIDGE MODIFICATION<br>CITY OF CHESTER |
|---|---|

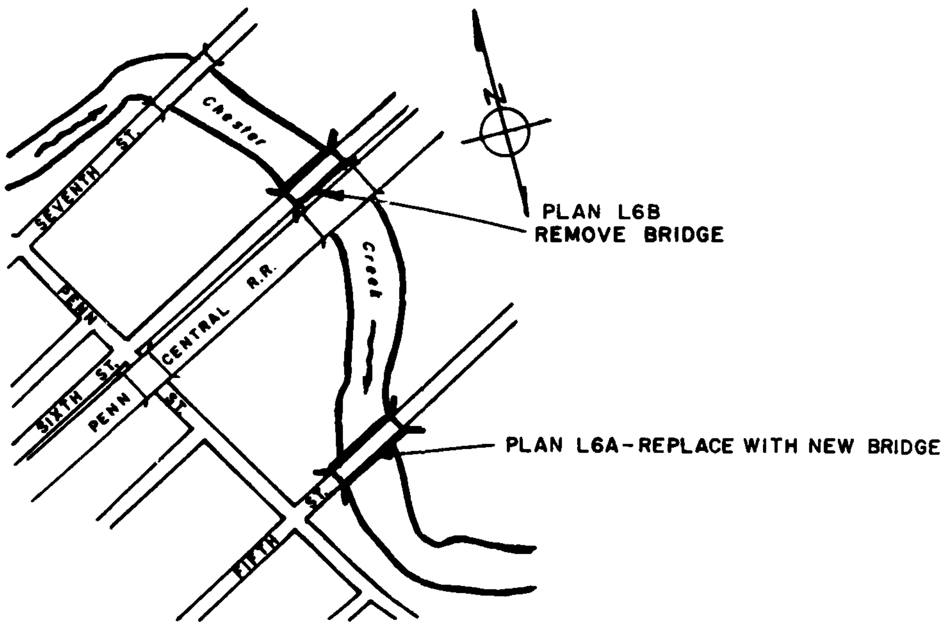
# DESCRIPTION

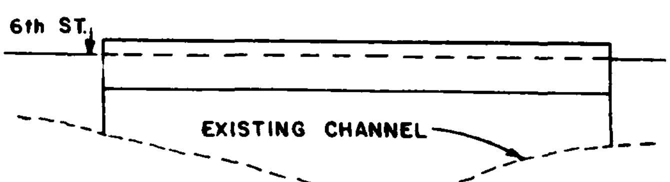
**PLAN** These plans consist of modifications to two bridges in the City of Chester to accomodate the natural capacity of the Creek. Plan L6A calls for replacement of the existing 80 foot single span at 5th Street with a 105 foot single span. Maintenance of the new bridge would consist of periodic inspection and repair. Plan L6B consists of the permanent removal of the 120 foot single span bridge at 6th Street. The traffic now carried by that bridge could be handled by the existing 5th Street bridge.

**LOCATION** City of Chester

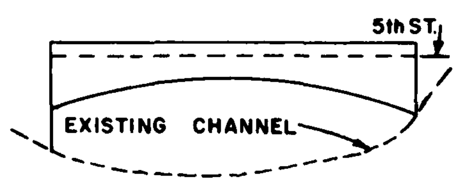
**PROJECT LIMITS** 5th or 6th Street bridges

**PROTECTION LIMITS** 5th or 6th Street bridge to Chester Township (Toby Farms)




**6TH STREET BRIDGE**




**5TH STREET BRIDGE**

| L6A and L6B | BRIDGE MODIFICATION<br>CITY OF CHESTER |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Varies at different locations

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Plans L6A and L6B reduce the 2-18 feet of flooding along the Creek by up to 3-1/2 feet and up to 1 foot, respectively

**DAMAGE LEVELS** L6A eliminates $2,538,000 of the $9,304,000 in damages and L6B eliminates $546,000 of this amount

## ECONOMICS

| | L6A | L6B |
|---|---|---|
| **PROJECT COST (TOTAL)** | $447,000 | $56,000 |
| construction | 447,000 | 56,000 |
| lands and relocation | 0 | 0 |
| recreation | * | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 28,900 | $ 3,600 |
| interest and amortization | 28,900 | 3,600 |
| operation and maintenance | Normal Inspection & Repair (minimal cost) | |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 77,000 | $22,500 |
| flood control | 77,000 | 22,500 |
| recreation | * | * |
| **BENEFIT/COST RATIO** | | |
| FLOOD CONTROL ONLY | 2.7 | 6.3 |
| FLOOD CONTROL & RECREATION | * | * |

* Not estimated since recreation facilities can not be provided by project.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Minor reduction of most flood related problems.
- Increased traffic over 5th Street bridge and local streets under Plan L6B.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 19% and 5% reduction (for L6A and L6B, respectively) of the $412,500 in annual damages in the areas protected by these alternatives.
- Slight reduction in restrictions to economic growth in business and taxable property located in flood plain fringe areas.

## CONCLUSIONS

These alternatives provide some protection, and are economically justified. The replacement of bridges is the responsibility of local interests. They were eliminated from further consideration.

| L6C and L6D | BRIDGE MODIFICATIONS<br>CITY OF CHESTER |
|---|---|

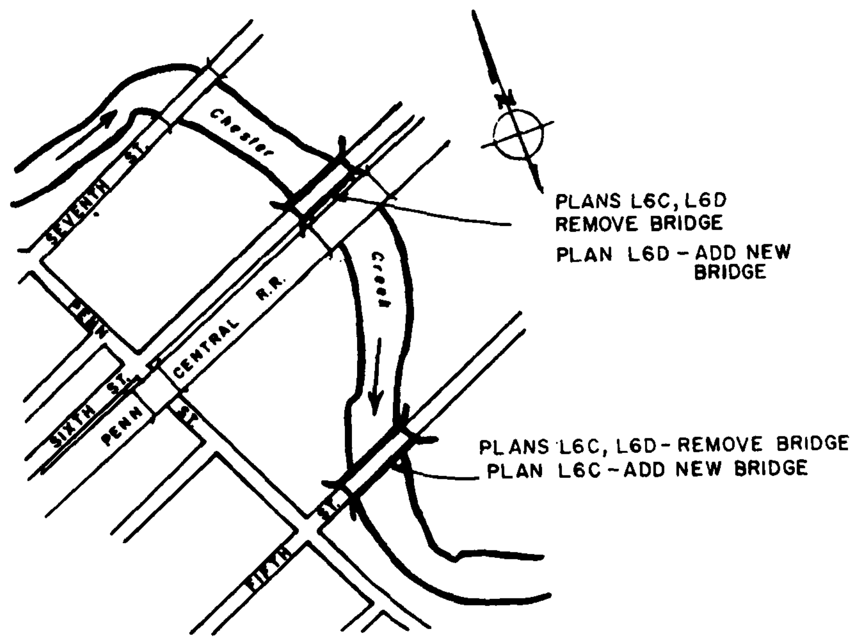
## DESCRIPTION

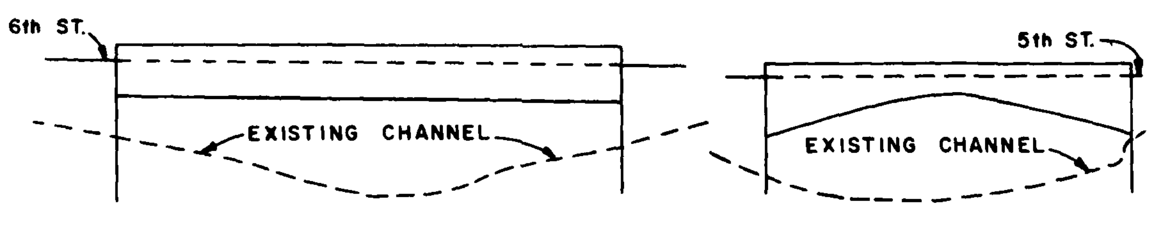
**PLAN** These plans consist of modifications to two bridges in the City of Chester to accomodate the natural capacity of the Creek. Both plans call for removal of the existing single span bridges (80 foot and 120 foot) at 5th and 6th Streets. Under Plan L6C the 6th Street bridge would not be replaced and a 105 foot single span bridge would be built at 5th Street to handle the traffic now using both bridges. Under plan L6D the 5th Street bridge would not be replaced, and a 145 foot single span bridge would be built at 5th Street to handle traffic now using both bridges. Maintenance would consist of periodic inspections and repairs.

**LOCATION** City of Chester

**PROJECT LIMITS** 5th or 6th Street bridges

**PROTECTION LIMITS** 5th Street bridge to Chester Township (Toby Farms)




6th STREET BRIDGE

5th STREET BRIDGE

| L6C and L6D | BRIDGE MODIFICATION<br>CITY OF CHESTER |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Varies at different locations

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Both plans reduce the 2-18 feet of flooding along the Creek by up to 3-1/2 feet

**DAMAGE LEVELS** L6C eliminates $3,375,000 of the $9,304,000 in damages and L6D eliminates $3,477,000 of this amount

## ECONOMICS

| | L6C | L6D |
|---|---|---|
| **PROJECT COST (TOTAL)** | $503,000 | $484,000 |
| construction | 503,000 | 484,000 |
| lands and relocation | 0 | 0 |
| recreation | * | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 32,500 | $ 31,200 |
| interest and amortization | 32,500 | 31,200 |
| operation and maintenance | Normal Inspection & Repair (minimal cost) | |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 93,400 | $ 88,700 |
| flood control | 93,400 | 88,700 |
| recreation | * | * |
| **BENEFIT / COST RATIO** | | |
| FLOOD CONTROL ONLY | 2.9 | 2.8 |
| FLOOD CONTROL & RECREATION | * | * |

* Not estimated since recreation facilities can not be provided by project

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Some reduction of most flood related problems.
- Increased traffic over 5th Street bridge under Plan L6C and over 6th Street bridge under Plan L6D.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 23% and 22% reduction (respectively for L6C and L6D) of the $412,500 in annual damages in the areas protected by these alternatives.
- Slight reduction in restrictions to economic growth in business and taxable property located in flood plain fringe areas.

## CONCLUSIONS

These alternatives provide some protection and are economically justified. The replacement of bridges is the responsibility of local interests. They were eliminated from further consideration.

| L6E | CHANNEL CLEARANCE<br>CITY OF CHESTER |
|---|---|

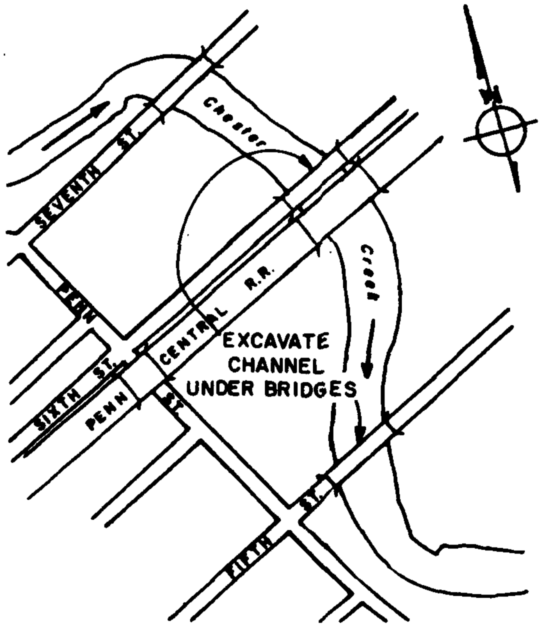
# DESCRIPTION

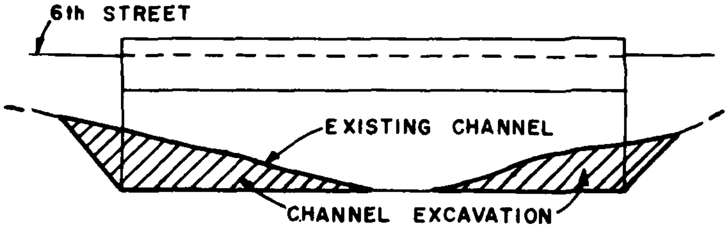
**PLAN** The plan consists of the initial and periodic removal of material from the channel under the 5th and 6th Street bridges to achieve the maximum flood carrying capability of those bridges. Maintenance of the project would be a local responsibility and would consist of keeping the bridge openings clear at all times. Normal deposition of materials would require that maintenance be performed at 5 year intervals. More frequent maintenance may be necessary.

**LOCATION** City of Chester

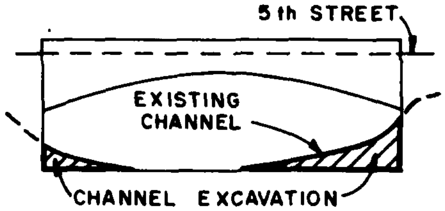
**PROJECT LIMITS** Downstream of 5th Street to upstream of 6th Street

**PROTECTION LIMITS** 5th Street to Chester Township (Toby Farms)




6TH STREET BRIDGE




5TH STREET BRIDGE

| L6E | CHANNEL CLEARANCE<br>CITY OF CHESTER |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Varies at different locations

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Reduces the 2-18 feet of flooding along the Creek by 1/2 to 1 foot

**DAMAGE LEVELS** Eliminates $1,073,000 of the $9,304,000 in damages

## ECONOMICS

| | |
|---|---|
| **PROJECT COST (TOTAL)** | $16,000 |
| construction | 16,000 |
| lands and relocation | Minimal Cost |
| recreation | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 3,000 |
| interest and amortization | 1,000 |
| operation and maintenance | 2,000 |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $40,500 |
| flood control | 40,500 |
| recreation | * |
| **BENEFIT / COST RATIO** | |
| FLOOD CONTROL ONLY | 13.5 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

·Slight reduction of flood related problems.

## REGIONAL / ECONOMIC EFFECTS (major)

·A 10% reduction of the $412,500 in annual flood damages in the areas protected by this alternative.

·Slight reduction in restrictions to economic growth in business and taxable property located in flood plain fringe areas.

## CONCLUSIONS

This alternative can provide some protection and is economically justified. The removal of sediment buildup at bridges is part of the normal maintenance of those bridges and is the responsibility of local interests. It was eliminated from further consideration.

| L6F | CHANNEL CLEARANCE<br>CITY OF CHESTER AND BOROUGH OF UPLAND |
|---|---|

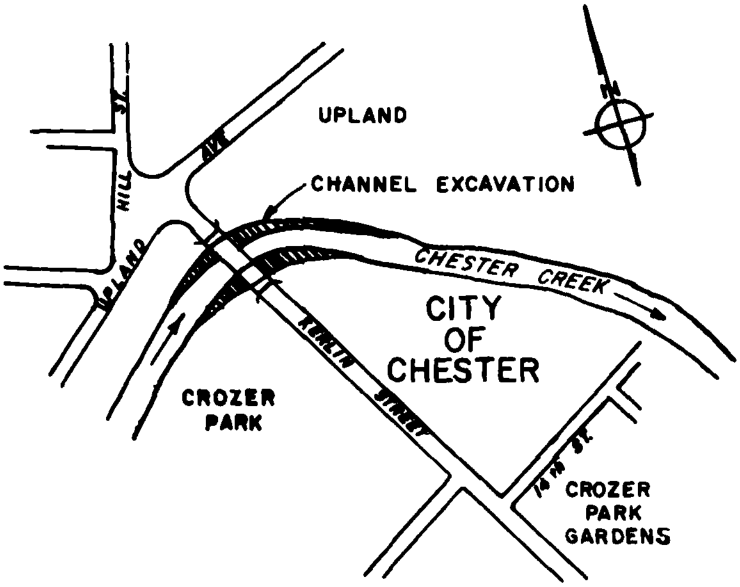
## DESCRIPTION

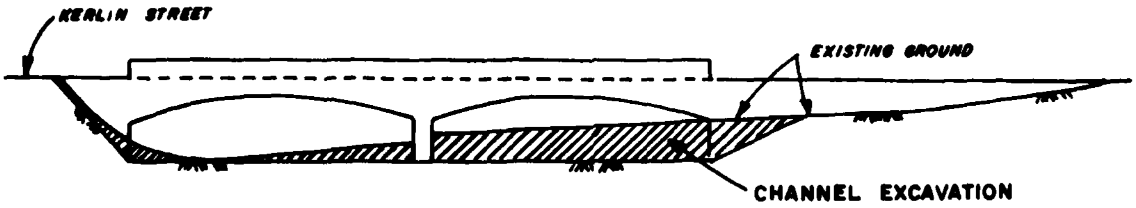
**PLAN** This plan consists of the initial and periodic removal of material from the channel at Kerlin Street bridge to achieve the maximum flood carrying capability of that bridge. Excavation would extend from 250 feet upstream to 400 feet downstream of Kerlin Street. Maintenance of the project would be a local responsibility and would consist of keeping the bridge opening and modified channel clear at all times. Normal deposition of materials would require that maintenance be performed at 5 year intervals. More frequent maintenance may be required.

**LOCATION** City of Chester and Borough of Upland

**PROJECT LIMITS** Immediately upstream and downstream of Kerlin Street

**PROTECTION LIMITS** Crozer Park Gardens to Toby Farms



| L6F | CHANNEL CLEARANCE<br>CITY OF CHESTER AND BOROUGH OF UPLAND |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Varies at different locations

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Reduces the 2-18 feet of flooding along the Creek by less than 1 foot

**DAMAGE LEVELS** Eliminates $53,000 of the $4,917,000 in damages

## ECONOMICS

| | |
|---|---|
| PROJECT COST (TOTAL) | $35,000 |
| construction | 32,000 |
| lands and relocation | 3,000 |
| recreation | * |
| AVERAGE ANNUAL COSTS (TOTAL) | $ 3,800 |
| interest and amortization | 2,300 |
| operation and maintenance | 1,500 |
| AVERAGE ANNUAL BENEFITS (TOTAL) | $15,500 |
| flood control | 15,500 |
| recreation | * |
| BENEFIT / COST RATIO | |
| FLOOD CONTROL ONLY | 4.1 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

·Slight reduction of most flood related problems.

## REGIONAL / ECONOMIC EFFECTS (major)

·A 7% reduction of the $230,000 in annual flood damages in the areas protected by this alternative.
·Slight reduction in restrictions to economic growth in business and taxable property located in flood plain fringe areas.

## CONCLUSIONS

This alternative is economically justified. However, the removal of sediment and debris buildup at bridges is part of the normal maintenance of those bridges and is the responsibility of local interests. It was eliminated from further consideration.

| L7A and L7B | CHANNEL EXCAVATION<br>DELAWARE RIVER TO DUTTON MILL ROAD |
|---|---|

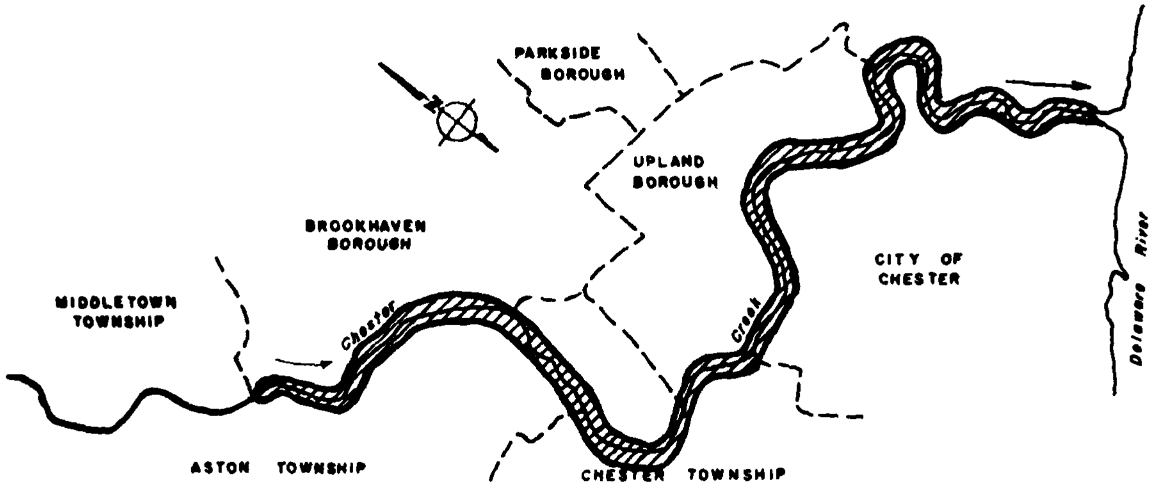
# DESCRIPTION

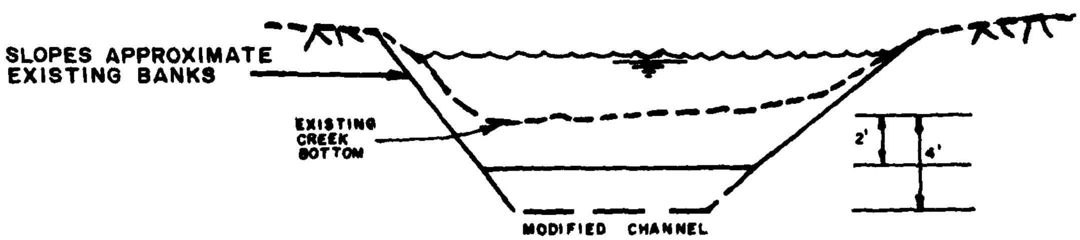
**PLAN** These plans involve the dredging of 27,600 feet of Chester Creek to depths of 2 feet (Plan L7A) and 4 feet (Plan L7B) below the existing bottom. The natural, banked channel would be maintained at the existing top width, which varies from 40 to 70 feet, and sideslopes would be dredged at slopes similar to existing conditions. Maintenance dredging, a local responsibility, would consist of the removal of materials from the channel at 5 year intervals.

**LOCATION** City of Chester, Borough of Upland, Chester Township, Brookhaven Borough, Aston Township

**PROJECT LIMITS** Delaware River to Dutton Mill Road

**PROTECTION LIMITS** Delaware River to Dutton Mill Road




The analysis of these alternatives was based on data on sediment yield presented in House Document 522-87-2, the Delaware River Basin Report (Appendix H, Fluvial Sediment), April 1962. Based on this data, maintenance dredging will be required once every 5 years.

| L7A and L7B | CHANNEL EXCAVATION<br>DELAWARE RIVER TO DUTTON MILL ROAD |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Varies at different locations

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Plans L7A and L7B reduce the 2-18 feet of flooding along the Creek by up to 1 foot and up to 2 feet, respectively

**DAMAGE LEVELS** L7A eliminates $1,068,000 of the $10,693,000 in damages and L7B eliminates $2,844,000 of this amount

## ECONOMICS

| | L7A | L7B |
|---|---|---|
| **PROJECT COST (TOTAL)** | $1,588,000 | $2,627,000 |
| construction | 1,588,000 | 2,627,000 |
| lands and relocation | ** | ** |
| recreation | * | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 109,000 | $ 176,000 |
| interest and amortization | 102,500 | 169,500 |
| operation and maintenance | 6,500 | 6,500 |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 95,200 | $ 132,100 |
| flood control | 95,200 | 132,100 |
| recreation | * | * |
| **BENEFIT/COST RATIO** | | |
| FLOOD CONTROL ONLY | 0.87 | 0.75 |
| FLOOD CONTROL & RECREATION | * | * |

* Not estimated since recreation facilities can not be provided by project
** Not estimated due to obvious economic infeasibility

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems for large areas.
- Disruption to flora and fauna by channel excavation.
- Alteration to the natural environment by the disposal of excavated materials for both initial and maintenance dredging.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 20% and 28% reduction (for L7A and L7B, respectively) of the $465,000 in annual flood damages in the area downstream of Dutton Mill Road.
- Annual maintenance cost for the alternative.
- Reduction of restrictions to economic growth in business and taxable property located in flood plain fringe areas.

## CONCLUSIONS

These alternatives provide some protection. They are not economically justified and have adverse environmental effects. They were eliminated from further consideration.

| L7C and L7D | CHANNEL EXCAVATION<br>9TH STREET TO TOBY FARMS |
|---|---|

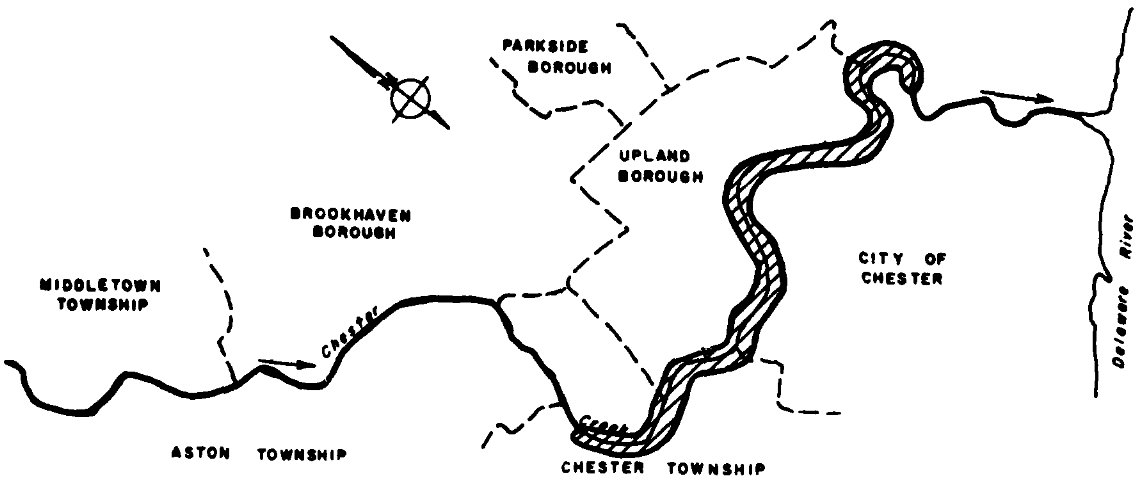
# DESCRIPTION

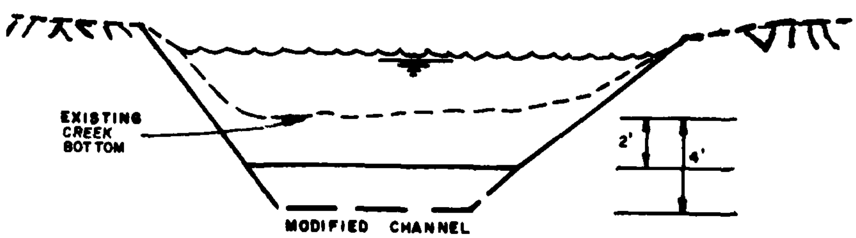
**PLAN** These plans involve the dredging of 13,500 feet of Chester Creek to depths of 2 feet (Plan L7C) and 4 feet (Plan L7D) below the existing bottom. The natural, banked channel would be maintained at the exsiting top width, which varies from 40 to 70 feet, and sideslopes would be dredged at slopes similar to existing conditions. Maintenance dredging, a local responsibility, would consist of the removal of materials from the channel at 5 year intervals.

**LOCATION** City of Chester, Borough of Upland, Chester Township

**PROJECT LIMITS** 9th Street to Toby Farms

**PROTECTION LIMITS** 9th Street to Toby Farms




The analysis of these alternatives was based on data on sediment yield presented in House Document 522-87-2, the Delaware River Basin Report (Appendix H, Fluvial Sediment), April 1962. Based on this data, maintenance dredging will be required once every 5 years.

| L7C and L7D | CHANNEL EXCAVATION<br>9TH STREET TO TOBY FARMS |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Varies at different locations

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Plans L7C and L7D reduce the 12-18 feet of flooding along the Creek by up to 1 foot and up to 2 feet, respectively

**DAMAGE LEVELS** L7C eliminates $515,000 of the $3,561,000 in damages and L7D eliminates $1,222,000 of this amount

## ECONOMICS

| | L7C | L7D |
|---|---|---|
| **PROJECT COST (TOTAL)** | $902,00 | $1,517,000 |
| construction | 902,000 | 1,517,000 |
| lands and relocation | ** | ** |
| recreation | * | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 64,700 | $ 104,400 |
| interest and amortization | 58,200 | 97,900 |
| operation and maintenance | 6,500 | 6,500 |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 42,700 | $ 63,800 |
| flood control | 42,700 | 63,800 |
| recreation | * | * |
| **BENEFIT/COST RATIO** | | |
| FLOOD CONTROL ONLY | 0.66 | 0.61 |
| FLOOD CONTROL & RECREATION | * | * |

* Not estimated since recreation facilities can not be provided by project
** Not estimated due to obvious economic infeasibility

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems
- Disruption to flora and fauna by channel excavation.
- Alteration to the natural environment by the disposal of excavated materials for both initial and maintenance dredging.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 24% and 36% reduction (for L7C and L7D, respectively) of the $178,000 in annual flood damages in the area downstream of Toby Farms.
- Annual maintenance cost for the alternative.
- Reduction of restrictions to economic growth in business and taxable property located in flood plain fringe areas.

## CONCLUSIONS

These alternatives provide some protection. They are not economically justified and have adverse environmental effects. They were eliminated from further consideration.

| L8A and L8B | LEVEE<br>TOBY FARMS |
|---|---|

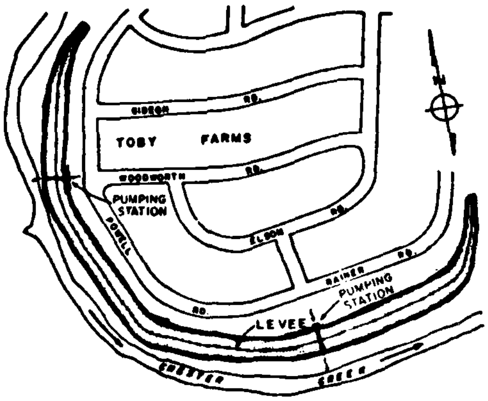
## DESCRIPTION

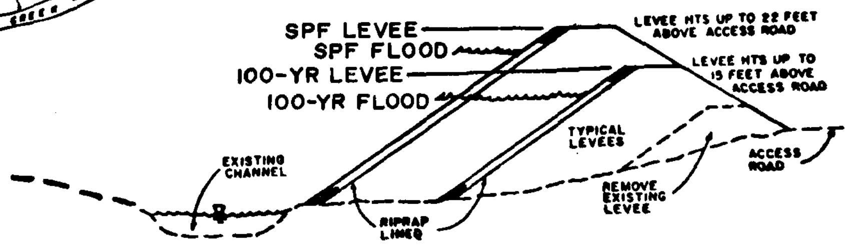
**PLAN** These plans provide protection to 148 homes through the construction of 2800 feet of earth levee (L8A), and to 258 homes with a 2900 foot long levee (L8B). An existing non-Federal levee which was built following the September 1971 flood would be removed. An interior drainage system would be provided to collect and pump rainfall runoff accumulating behind the levee. The levees would be protected against erosion by provision of a riprap (rock) lining. A picnic area and hiking trail could be provided on the 4.5 acres of land needed for either of these plans.

**LOCATION** Chester Township

**PROJECT LIMITS** Toby Farms residential development

**PROTECTION LIMITS** Toby Farms residential development




Drainage would be provided at two low spots. Flap-gated culverts would seal the drains during flood flows in Chester Creek. Once the Creek rises above the drains, interior storm water would be removed by self-activating pumps. Riprap slope protection would be provided along the stream side of the levee. Bank velocities along a railroad embankment across the stream from the project will only increase about 5% due to the levee, and therefore no bank protection would be needed. Relocation of utility lines may be a source of added costs.

| L8A and L8B | LEVEE<br>TOBY FARMS |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** L8A - 100 year flood
L8B - Standard Project Flood (SPF)

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** L8A protects against the 100 year flood level which would be up to 12 feet above the access road and L8B protects up tc a level 7 feet higher

**DAMAGE LEVELS** L8A eliminates all of the $1,346,000 in damages and L8B eliminates additional damages totaling $3,156,000

## ECONOMICS

| | L8A | L8B |
|---|---|---|
| PROJECT COST (TOTAL) | $844,000 | $1,173,000 |
| construction | 790,000 | 1,119,000 |
| lands and relocation | 16,000 | 16,000 |
| recreation | 38,000 | 38,000 |
| AVERAGE ANNUAL COSTS (TOTAL) | $ 58,800 | $ 82,700 |
| interest and amortization | 54,500 | 75,700 |
| operation and maintenance | 4,300 | 7,000 |
| AVERAGE ANNUAL BENEFITS (TOTAL) | $114,900 | $ 135,900 |
| flood control | 82,200 | 103,200 |
| recreation | 32,700 | 32,700 |
| BENEFIT/COST RATIO | | |
| FLOOD CONTROL ONLY | 1.5 | 1.3 |
| FLOOD CONTROL & RECREATION | 2.0 | 1.6 |

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems.
- Elimination of psychological stresses from the threat of floods by SPF levee.
- Prevention of the deterioration of existing flood plain structures.
- Alteration to the natural environment at the project area and quarry sites.
- Visual obstruction and reduced access to the Creek.
- Increased opportunity for recreation, conservation, and natural development.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 71% and 89% reduction (for L8A and L8B, respectively) of the $116,000 in annual damages in Toby Farms.
- Annual maintenance cost for the alternative.

## CONCLUSIONS

These alternatives can provide high levels of protection and are economically justified. However, neither Delaware County nor Chester Township could provide sponsorship and they were eliminated from further consideration.

| L9 | LEVEE<br>CENTENNIAL HOME CENTER (AHREN'S LUMBER CO.) |
|---|---|

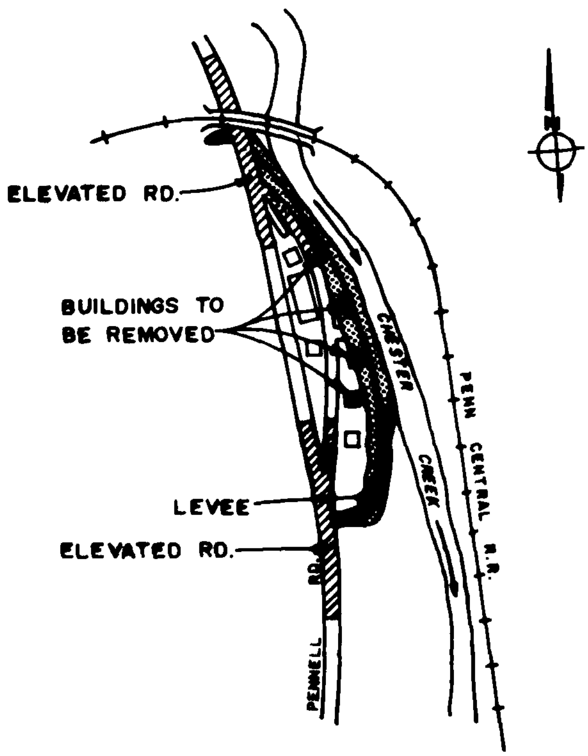
## DESCRIPTION

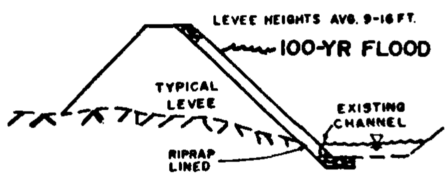
**PLAN** This plan provides protection to the Centennial Home Center (Ahren's Lumber Co.) through the construction of 1350 feet of earth levee and the raising of Pennell Road, by up to 3 feet, at two separate locations. The raised highway embankment would serve as a levee. Four storage structures of the Centennial Home Center would have to be removed and relocated to flood free sites to provide sufficient space for levee construction. The levee and stream banks would be protected against erosion by provision of a riprap (rock) lining.

**LOCATION** Aston Township

**PROJECT LIMITS** Centennial Home Center

**PROTECTION LIMITS** Centennial Home Center




A floodwall plan was considered which would not involve the relocation of buildings. However, a levee plan was found to be less expensive. Potential problems involve traffic control during the raising of Pennell Road. Interior drainage facilities would be needed to drain the area but no interior drainage plan was developed because the plan is not economically justified.

| L9 | LEVEE<br>CENTENNIAL HOME CENTER (AHREN'S LUMBER CO.) |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** 100 year flood

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Protects against the 100 year flood level which would be up to 13 feet above the bank

**DAMAGE LEVELS** Eliminates all of the $546,000 in damages

## ECONOMICS

| | |
|---|---|
| PROJECT COST (TOTAL) | $579,000 |
| construction | 525,000 |
| lands and relocation | 54,000 |
| recreation | * |
| AVERAGE ANNUAL COSTS (TOTAL) | $ 37,400 |
| interest and amortization | 37,400 |
| operation and maintenance | ** |
| AVERAGE ANNUAL BENEFITS (TOTAL) | $ 17,000 |
| flood control | 17,000 |
| recreation | * |
| BENEFIT / COST RATIO | |
| FLOOD CONTROL ONLY | 0.47 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project.

** Not estimated due to obvious infeasibility

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems to the Centennial Home Center only.
- Retardation of the deterioration of existing flood plain structures at the Home Center.
- Alteration to the natural environment at the project area and at the sites used to supply materials for the levee project.
- Visual obstruction and reduced access to the Creek.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 60% reduction of the $29,000 in annual damages at the Centennial Home Center.
- Elimination of restrictions to economic growth of this business.

## CONCLUSIONS

This alternative can provide a high level of protection. However, it is not economically justified and has adverse environmental and social effects. It was eliminated from further consideration.

| L10A and L10B | LEVEE, FLOODWALLS AND BRIDGE MODIFICATIONS LENNI |
|---|---|

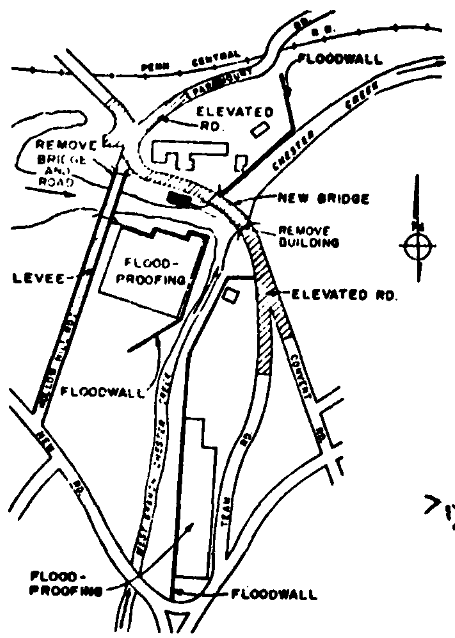
# DESCRIPTION

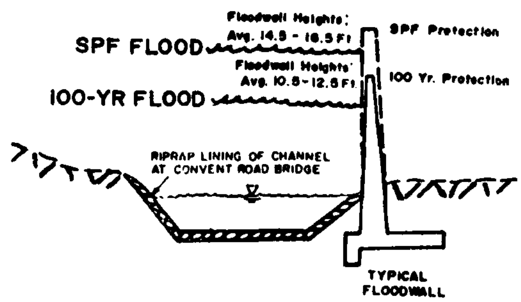
**PLAN** These plans provide protection to 4 businesses. They include construction of 2250 feet of concrete floodwall, and 370 feet of earth levee. Roadways would be elevated to serve as levees. The Hollow Hill Road bridge would be removed and the Convent Road bridge would be replaced. Buildings would be flood proofed by sealing openings and by strengthening exterior walls to act as floodwalls. An interior drainage system will be provided to remove storm water from behind the project. Riprap (rock) lining would be placed on levees and channel sections, where required, to prevent erosion. One commercial building would be relocated.

**LOCATION** Aston Township, Middletown Township

**PROJECT LIMITS** Convent Road to Hollow Hill Road (Main Stem, Chester Creek) and to New Road (West Branch, Chester Creek)

**PROTECTION LIMITS** Commercial establishments along the Main Stem and West Branch of Chester Creek in the Lenni area.




Due to the limited capacities the Hollow Hill and Convent Road Bridges to pass floods, the key to providing flood protection in the area is replacing these bridges. New bridges at both Hollow Hill and Convent Road could not be economically justified; therefore, only the Convent Road Bridge was replaced. The large industrial buildings along the east bank of the West Branch would be flood proofed by a floodwall above their existing foundation. The building located between Chester and West Chester Creeks at their confluence would also be flood proofed by a combination of sealing openings, levee an floodwalls. Normal plant operations at this building may have to be modified during construction.

| L10A and L10B | LEVEE, FLOODWALLS AND BRIDGE MODIFICATIONS<br>LENNI |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** L10A - 100 year flood
L10B - standard project flood

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** L10A protects against the 100 year flood level which would be up to 12 feet above the bank and L10B protects up to a level 4 feet higher

**DAMAGE LEVELS** L10A eliminates all of the $1,365,000 of damages and L10B eliminates additional damages totaling $1,734,000

## ECONOMICS

| | L10A | L10B |
|---|---|---|
| **PROJECT COST (TOTAL)** | $1,541,000 | $1,958,000 |
| construction | 1,257,000 | 1,590,000 |
| lands and relocation | 284,000 | 368,000 |
| recreation | * | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 104,400 | $ 133,700 |
| interest and amortization | 99,500 | 126,400 |
| operation and maintenance | 4,900 | 7,300 |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 133,600 | $ 136,500 |
| flood control | 133,600 | 136,500 |
| recreation | * | * |
| **BENEFIT / COST RATIO** | | |
| FLOOD CONTROL ONLY | 1.3 | 1.02 |
| FLOOD CONTROL & RECREATION | * | * |

* Not estimated since recreation facilities can not be provided by project

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems to businesses in Lenni area.
- Elimination of psychological stresses from the threat of floods by SPF protection
- Prevention of the deterioration of existing flood plain structures.
- Alteration to the natural environment at the project area and quarry sites.
- Visual obstruction and reduced access to Creek.

## REGIONAL / ECONOMIC EFFECTS (major)

- An 89% and 91% reduction (for L10A and L10B, respectively) of the $150,000 in annual flood damages in the Lenni area.
- Elimination (L10A) or reduction (L10B) in restrictions to the expansion of facilities located in the industrial area with a potential for increased employment and a more stable tax base.

## CONCLUSIONS

These alternatives can provide high levels of protection. They are **marginally** economically justified, but have adverse environmental and social effects. Neither Delaware County nor Aston and Middletown Townships could provide sponsorship for these plans and they were eliminated from further consideration.

| L11 | LEVEES, FLOODWALLS, BRIDGE AND CHANNEL MODIFICATIONS ASTON MILLS |
|---|---|

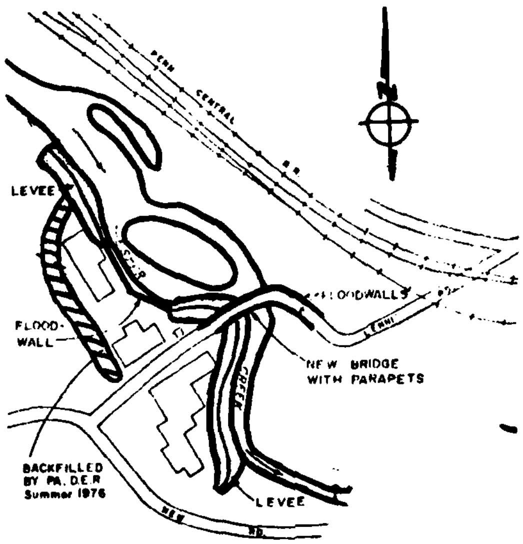
## DESCRIPTION

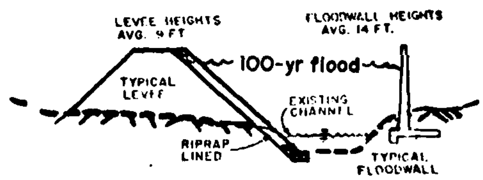
**PLAN** This plan provides protection to 4 businesses and 1 home through construction of 770 feet of earth levee and 430 feet of floodwalls. The floodwall is constructed where space is limited so as to preserve existing buildings. The levee and stream banks would be protected with a riprap (rock) lining in the immediate vicinity of Lenni Road. In addition, a new, higher Lenni Road Bridge would be constructed with high walls and floodwalls to prevent overtopping of the road.

**LOCATION** Aston Township, Middletown Township, Chester Heights Borough

**PROJECT LIMITS** Aston Mills Area

**PROTECTION LIMITS** Buildings on the right bank (looking downstream) in the Aston Mills area near Lenni Road




An alternate plan was also considered. This plan involved straightening the existing channel both upstream and downstream of the Lenni Road Bridge; construction of 940 feet of a 10 -foot high levee; backfilling the old channel; excavation of the new channel; and parapet walls for the existing bridge. A cursory analysis indicated an obvious lack of economic justification.

Potential problems of both plans involve access to the industrial buildings. Normal access may be interrupted during bridge construction and require an alternate route to the plants. In addition, motorists will experience some inconvenience from detours around the construction site. Interior drainage facilities would be needed to drain the area. However, an interior drainage plan was not developed due to the plan not being economically justified.

| L11 | LEVEES, FLOODWALLS, BRIDGE AND CHANNEL MODIFICATION ASTON MILLS |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** 100 year flood

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Protects against the 100 year flood level which would be up to 12 feet above the bank

**DAMAGE LEVELS** Eliminates all of the $157,000 in damages

## ECONOMICS

| | |
|---|---|
| **PROJECT COST (TOTAL)** | $931,000 |
| construction | 920,000 |
| lands and relocation | 11,000 |
| recreation | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 60,100 |
| interest and amortization | 60,100 |
| operation and maintenance | ** |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 19,800 |
| flood control | 19,800 |
| recreation | * |
| **BENEFIT / COST RATIO** | |
| FLOOD CONTROL ONLY | 0.33 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project
** Not estimated due to obvious economic infeasibility

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems to industries in Aston Township
- Reduction of psychological stresses from the threat of floods.
- Petardation of the deterioration of existing flood plain structures.
- Alteration to the natural environment at the project area and at the sites used to supply materials for construction.
- Visual obstruction and reduced access to Creek.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 90% reduction of the $22,000 in annual damages in Aston Mills area.
- Elimination of restrictions to economic growth of business and taxable property located in Aston Township with a potential for increased employment and a more stable tax base.

## CONCLUSIONS

This alternative can provide a very high level of protection. However, it is not economically justified and has adverse environmental and social effects. It was eliminated from further consideration.

## FLOODWATER/STORM DRAINAGE PLANS

57. Two areas in the Chester Creek Basin have experienced flooding which was a combination of both out-of-bank and storm water drainage type flooding. One area includes Lukens, Maris, and Crozer Runs in the Borough of Upland. The other area is the Goose Creek Watershed within the Borough of West Chester and West Goshen Township.

58. LUKENS, MARIS, AND CROZER RUNS. A Corps of Engineers reconnaissance report completed in 1966 identified that a 25-year storm water sewer system would solve most of the flooding problems along Lukens, Maris, and Crozer Run.* At that time Federal participation could not be recommended since it was determined the plan was designed to prevent damages caused by runoff originating within the community.

59. Subsequent to this report the Commonwealth of Pennsylvania conducted a study on this area in 1968-1969.** The study recommended a storm water sewer system with approximately a 25-year frequency storm level of design. The project has been constructed. All three streams were channelled through concrete pipe ranging in diameter from 42 to 84 inches. A stilling basin, protected with riprap, was installed on Maris Run. Inlets and transition structures were constructed on all the streams to pick up local drainage and to provide connections to existing pipes.

60. A reanalysis of the problems was conducted as part of the Chester Creek Study. This work confirmed that most of the fluvial flooding along these three Runs will be solved with the State's storm water sewer projects. Residual damages would not be sufficient to justify any additional improvements. However, flooding can still be caused by floodwaters backing up these three Runs from the Chester Creek. Solution of this backwater flooding was included in study for the Borough of Upland's flood problems.

61. GOOSE CREEK. The Goose Creek study area is a flat lowland area. A major portion of its recurrent flooding problems are caused by overland or drainage type flooding. Flooding is frequent with low levels of flooding causing most of the damages as shown below. These damages are the cumulative damages through the frequency shown as a percentage of the total existing average annual damages of $33,900.

* Reconnaissance Report; Flood Problem at Upland, Delaware County; Philadelphia District, U.S. Army Corps of Engineers; April 1966.
** Borough of Upland, Delaware County, Commonwealth of Pennsylvania, Flood Control Study; Justin and Courtney, Consultant Engineers for the Pennsylvania Department of Environmental Research.

| Flood % | Frequency Years | Cumulative Average Annual Damages | Cumulative Percent Average Ann. Damages |
|---|---|---|---|
| 50.0 | 2 | $ 22,800 | 17 |
| 10.0 | 10 | 87,000 | 65 |
| 5.0 | 20 | 103,100 | 77 |
| 3.3 | 30 | 109,800 | 82 |
| 2.5 | 40 | 113,800 | 85 |
| 2.0 | 50 | 117,800 | 88 |

62. Two previous studies have identified the flooding problem as a combination of storm water drainage and out-of-stream bank flooding.* Both studies identified a 50-year level of design to relieve most of the flooding. The proposed plans consisted primarily of storm sewer components with bridge or road culvert modifications. These findings on level of design and type of protection were confirmed by the Chester Creek Basin Study.

63. The existing storm water sewer is basically a 2-year system. Both West Chester and West Goshen officials indicate that the 50-year system recommended by the two studies is beyond the resources of their communities. These communities will increase the capacities of their existing facilities as part of their normal maintenance and facilities upgrading program. This upgrading will be far below the recommended 50-year design level; therefore, plans were considered under this study.

* Drainage Study of Goose Creek and West Washington Street area, West Chester Borough, Chester County, Pennsylvania; G.D. Houtman & Son, Media, Pennsylvania; September 13, 1972. Storm Drainage Study, East Branch Goose Creek Drainage Basin, prepared for Industrial Commercial Study Group; Smith, Chatman-Royce Associates, Malvern, Pennsylvania; October 23, 1973.

| L12. | CHANNEL MODIFICATION<br>GOOSE CREEK |
|---|---|

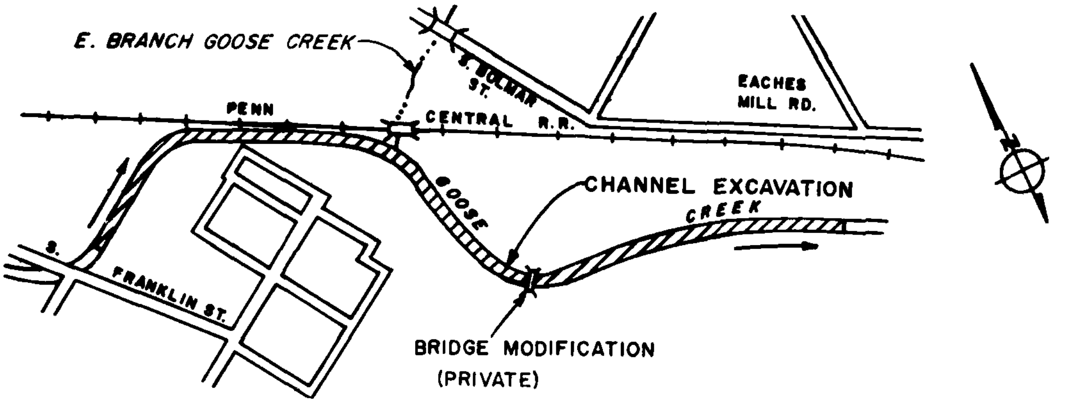
# DESCRIPTION

**PLAN** This plan involves the deepening and widening of the Main Stem, Goose Creek for a distance of about 3000 feet. A 10 foot wide trapezoidal, natural banked channel would be provided. This work would require the underpinning of a private bridge south of the railroad. The modified channel will have the capacity to carry a 50 year flow without coming out of bank.

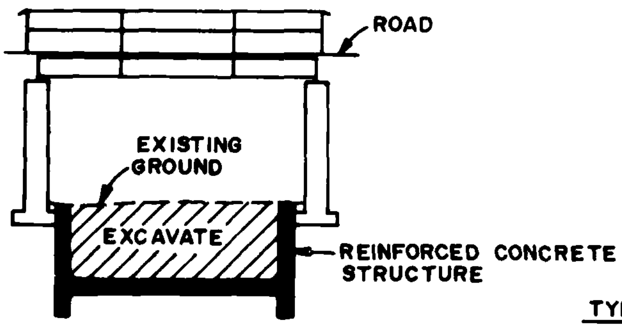
**LOCATION** West Chester Borough, West Goshen Township

**PROJECT LIMITS** 1200 feet above U. S. Route 322 to 100 feet below South Franklin St.

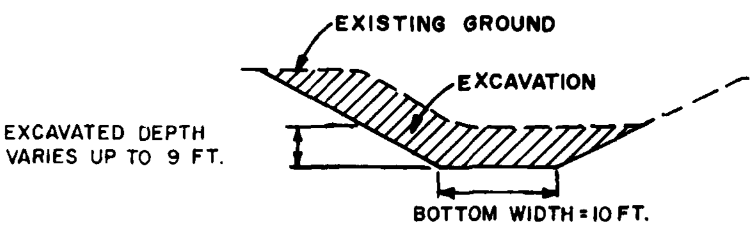
**PROTECTION LIMITS** Buildings along the Main Stem, Goose Creek from E. Rosedale to E. Nields St.




BRIDGE MODIFICATION




TYPICAL CHANNEL SECTION



| L12 | CHANNEL MODIFICATION<br>GOOSE CREEK |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Protects against the 50 year flood and provides varying levels of protection against greater events

**EFFECT ON THE 50 YEAR FLOOD**

**FLOODING LEVELS** Eliminates all flooding up to the 50 year level which would be up to 3 feet above the bank

**DAMAGE LEVELS** Eliminates all of the $116,600 in damages

## ECONOMICS

| | |
|---|---|
| PROJECT COST (TOTAL) | $158,000 |
| construction | 153,000 |
| lands and relocation | 5,000 |
| recreation | * |
| AVERAGE ANNUAL COSTS (TOTAL) | $ 10,200 |
| interest and amortization | 10,200 |
| operation and maintenance | ** |
| AVERAGE ANNUAL BENEFITS (TOTAL) | $ 5,500 |
| flood control | 5,500 |
| recreation | * |
| BENEFIT / COST RATIO | |
| FLOOD CONTROL ONLY | 0.54 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project.
** Not estimated due to obvious economic infeasibility.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems.
- Disruption to flora and fauna by channel excavation and disposal of materials.
- Alteration to the natural environment by the disposal of excavated materials for both project construction and maintenance.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 37% reduction of the $15,000 in annual damages in the areas protected by this alternative.
- Reduction in restrictions to economic growth in business and taxable property located in flood plain fringe areas.

## CONCLUSIONS

This alternative can provide some protection. However, it is not economically justified, and has adverse environmental effects. It was eliminated from further consideration.

| L13 | BOLMAR STREET BYPASS<br>GOOSE CREEK |
| --- | --- |

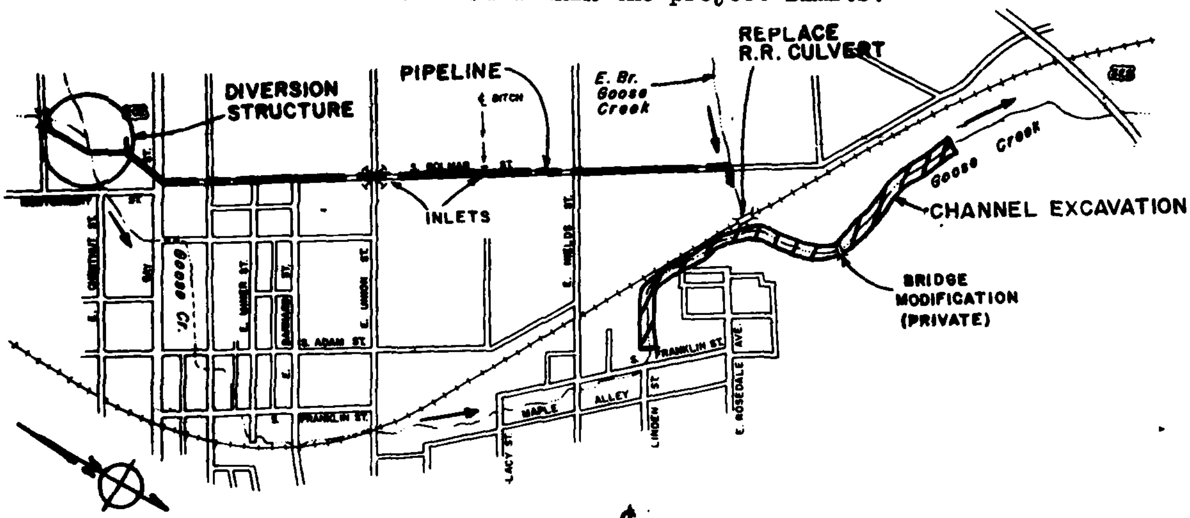
# DESCRIPTION

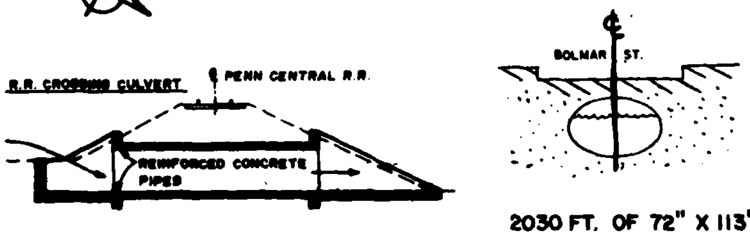
**PLAN** This plan involves a 4900 foot pipeline along Bolmar Street from the Main Stem to E. Branch Goose Creek which passes up to 50 year floods. The existing channel would carry non-flood flows. Inlets on Bolmar Street would relieve local drainage problems. One railroad culvert would be enlarged and 3000 feet of Goose Creek widened and deepened with one bridge modification. A similar plan but with a larger capacity pipe and channel so as to pass 100 year flows was also investigated. This plan was also not economically justified.

**LOCATION** West Chester Borough, West Goshen Township

**PROJECT LIMITS** Along Bolmar St. south of Union St. and along the Main Stem, Goose Creek from Montgomery Ave. to below the E. Branch

**PROTECTION LIMITS** Businesses and homes along Bolmar St. and the Main Stem of Goose Creek within the project limits.




**2030 FT. OF 72" X 113" PIPE AND 2870 FT. OF 77" X 121" PIPE**

The diversion of water to the East Branch will cause increased ponding above the railroad culvert and at the confluence of East Goose Creek with the main stem. To correct this problem the plan includes channelization of the main stem Goose Creek and construction of a new railroad culvert. In addition, land to retain the ponding water would be purchased to assure its availability.

| L13 | BOLMAR STREET BYPASS<br>GOOSE CREEK |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** 50 year flood

**EFFECT ON THE 50 YEAR FLOOD**

**FLOODING LEVELS** Eliminates all flooding up to the 50 year level which would be up to 5 feet above the bank

**DAMAGE LEVELS** Eliminates all of the $555,00 in damages

## ECONOMICS

| | |
|---|---|
| **PROJECT COST (TOTAL)** | $2,263,000 |
| construction | 2,115,000 |
| lands and relocation | 148,000 |
| recreation | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 146,100 |
| interest and amortization | 146,100 |
| operation and maintenance | ** |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 117,200 |
| flood control | 117,200 |
| recreation | * |
| **BENEFIT / COST RATIO** | |
| FLOOD CONTROL ONLY | 0.80 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project

** Not estimated due to obvious economic infeasibility

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems.
- Reduction of psychological stresses from the threat of floods.
- Reduction in the deterioration of existing flood plain structures.
- Temporary disruption of traffic along Bolmar Street
- Disruption to flora and fauna by channel excavation and disposal of material.

## REGIONAL / ECONOMIC EFFECTS (major)

- An 87% reduction of the $134,000 in annual damages in the areas protected by this alternative.
- Reduction in restrictions to economic growth in business and taxable property located along Bolmar Street and areas along Main Stem Goose Creek.

## CONCLUSIONS

This alternative can provide a high level of protection. However, it is not economically justified. **It was eliminated from further consideration.**

| L14 | SOUTH FRANKLIN STREET BYPASS<br>GOOSE CREEK |
|---|---|

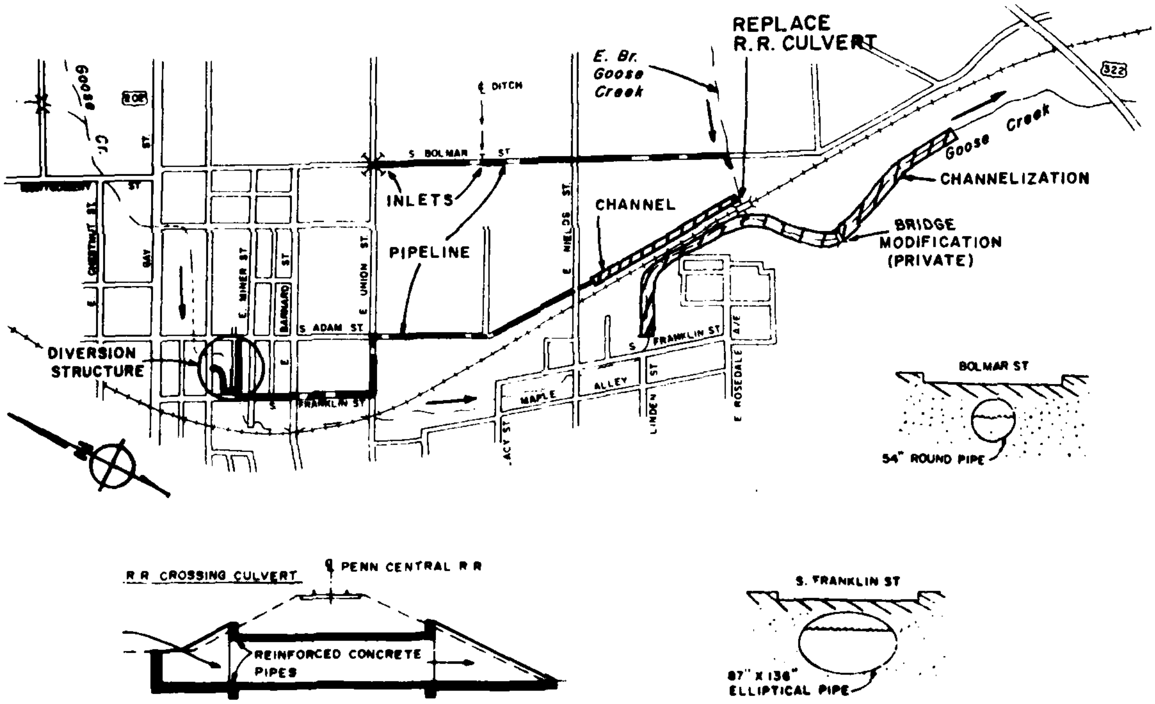
# DESCRIPTION

**PLAN** This plan involves diversion of up to 50 year flood flows on Goose Creek through 3300 feet of pipe along South Franklin St. and 700 feet of unlined, natural banked channel to the E. Branch. Drainage problems at Bolmar St. would be relieved by 2870 ft. of pipe with inlets which carries stormwater to the E. Branch, Goose Creek. To pass diverted flows without causing ponding problems and damages the railroad culvert on the E. Branch would be enlarged and 3000 ft. of channel downstream of S. Franklin St. would be modified, requiring under pinning of a private bridge. The existing channel would carry non-flood flows.

**LOCATION** West Chester Borough, West Goshen Township

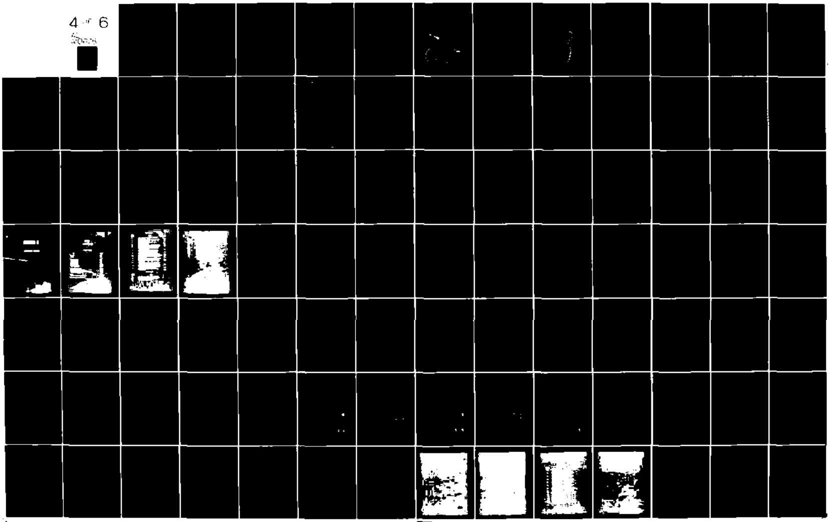
**PROJECT LIMITS** Along Bolmar St. south of Union St. and along the Main Stem, Goose Creek from Market St. to 1800 feet below the confluence with the East Branch

**PROTECTION LIMITS** Business and homes along Bolmar St. and the Main Stem of Goose Creek within the project limits.




The diverted flow at Cedar and South Franklin would be carried toward the E. Branch Goose Creek railroad outlet. As in alternative L13, the ponding area above the railroad would be purchased. The channelization on Goose Creek is designed to allow E. Branch Goose Creek to pass its flow with no additional ponding. Flooding levels south of the railroad and between Union Street and Linden Street would only be slightly reduced.

AD-A106 781 ARMY ENGINEER DISTRICT PHILADELPHIA PA F/G 13/2
WATER RESOURCES STUDY FOR METROPOLITAN CHESTER CREEK BASIN, PEN--ETC(U)
SEP 78
UNCLASSIFIED DAEN/NAP-12000/WRS-78/09 NL



| L14 | SOUTH FRANKLIN STREET BYPASS<br>GOOSE CREEK |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** 50 year flood

**EFFECT ON THE 50 YEAR FLOOD**

**FLOODING LEVELS** Eliminates all flooding up to the 50 year level which would be up to 5 feet above the bank

**DAMAGE LEVELS** Eliminates all of the $522,000 in damages

## ECONOMICS

| | |
|---|---|
| PROJECT COST (TOTAL) | $2,247,000 |
| construction | 2,106,000 |
| lands and relocation | 141,000 |
| recreation | * |
| AVERAGE ANNUAL COSTS (TOTAL) | $ 145,000 |
| interest and amortization | 145,000 |
| operation and maintenance | ** |
| AVERAGE ANNUAL BENEFITS (TOTAL) | $ 115,400 |
| flood control | 115,400 |
| recreation | * |
| BENEFIT/COST RATIO | |
| FLOOD CONTROL ONLY | 0.80 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project.
** Not estimated due to obvious economic infeasibility.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems.
- Reduction of psychological stresses from the threat of floods.
- Retardation of the deterioration of existing flood plain structures.
- Temporary disruption of traffic on Bolmar, S. Franklin and S. Adam Streets.
- Disruption to flora and fauna by channel excavation and disposal of material.

## REGIONAL / ECONOMIC EFFECTS (major)

- An 88% reduction of the $130,000 in annual damages in the areas protected by this alternative.
- Reduction in restrictions to economic growth in business and taxable property located along Bolmar Street and areas along Main Stem Goose Creek.

## CONCLUSIONS

This alternative can provide a high level of protection. However, it is not economically justified. **It was eliminated from further consideration.**

## COMBINATION PLANS

64. In order to determine if greater hydrologic, hydraulic, and economic efficiency can be derived by combinations of alternatives, systems analyses were performed on those combinations with a potential for increased efficiency. Most of the systems were a combination of alternative plans as described in the preceding paragraphs, but some include modifications. These modifications or changes to the basic plans were made in order to increase the efficiency of the systems.

65. A summary description of the combinations which were considered is presented in Table D-5. Systems S1A through S1D and S2A through S2D are primarily composites of previous basic alternatives with some changes. S3A through S3D are based on a modified alignment of the Chester Creek through the City of Chester with and without a variation between Third and Fifth Streets. The other additive components are bridge replacement and channel excavation variations. Systems S4A through S4C were a further refinement of the previous systems. After the results of the previous systems were reviewed, there was an indication that further refinements, such as deleting reservoir R6, may result in greater plan efficiency. These three systems (S4A through S4C) were therefore analyzed.

TABLE D-5
SUMMARY DESCRIPTIONS
COMBINATION PLANS

| System | Combinations of Basic Alternatives | Changes to Basic Alternatives | General Description |
|---|---|---|---|
| S1A | R6, R10 | None | Combination of two reservoirs. |
| S1B | R6, R13 | None | Combination of two reservoirs. |
| S1C | R10, R13 | None | Combination of two reservoirs. |
| S1D | R6, R10, R13 | None | Combination of three reservoirs. |
| S2A | R6, R10 | New 9th Street Bridge | Combination of two reservoirs; a new bridge at 9th Street. |
| S2B | R6, R10, L6C, L7B | New 7th & 9th Street Bridges | Combination of two reservoirs; removal of 6th Street Bridge; New 5th, 7th & 9th Street Bridge 4-foot channel modification from the confluence with the Delaware River to Dutton Mill Road. |
| S3A 1/ | | | New Channel Alignment; 6th Street out at Creek; new 5th, 7th & 9th Street Bridges . |
| S3B | S3A, L7B | 4-foot channel modification | New channel alignment; 6th Street out at Creek; new 5th, 7th & 9th Street Bridges ; 4-foot channel modification. |
| S3C | | Alternate channel alignment between 3rd & 5th Street Bridges | New 5th, 7th & 9th Street Bridges 6th Street out at Creek ; new channel alignment with alternate alignment between 3rd & 5th Streets |
| S3D | S3C, L7B | 4-foot channel modification | New 5th, 7th & 9th Street Bridges 6th Street out at Creek ; new channel alignment with alternate alignment between 3rd & 5th Streets ; 4-foot channel modification. |
| S4A | R10, S3A | None | One reservoir; new channel alignment; remove 5th & 9th Stree Bridges; new 5th, 7th & 9th Stree Bridges. |
| S4B | R10, L6C | New 7th & 9th Street Bridges | One reservoir; remove 6th Street Bridge; new 5th, 7th & 9th Street Bridges |
| S4C | R10, L6C, L7B | New 7th & 9th Street Bridges | One reservoir; remove 6th Street Bridge; new 5th, 7th and 9th Street Bridges ; 4-foot channel modification. |

1/ Recommended for further consideration.

| S1A, S1B, S1C, S1D | COMBINATION OF DRY RESERVOIRS |
|---|---|

# DESCRIPTION

**PLAN** System S1A combines dry reservoir plans R6 and R10. It covers 558 acres and requires the relocation 2-1/2 miles of road, 21 buildings, and utilities. System S1B combines plans R6 and R13. It covers 384 acres and relocates 2-3/4 miles of roads, 2 miles of railroad, 9 buildings, and utilities. System S1C combines plans R10 and R13. It covers 680 acres and relocates 4-1/4 miles of roads, 2 miles of railroad, 20 buildings, and utilities. System S1D combines plans R6, R10 and R13. It covers 680 acres and relocates 4-3/4 miles of road, 2 miles of railroad, 25 buildings, and utilities.

**LOCATION** Aston Township, Chester Heights Borough, Concord Township, Thornbury Township (DELCO), Thornbury Township (CHESCO)

**PROJECT LIMITS** Areas required for reservoir impoundment

**PROTECTION LIMITS** Dam sites to Delaware River.

HYDRAULIC EFFECTS

| Index Station | Existing Conditions 1/ | | | | | | Future Conditions 2/ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50-Year | | 100-Year | | SPF | | 50-Year | | 100-Year | | SPF | |
| | S 3/ | ΔS 4/ | S | ΔS | S | ΔS | S | ΔS | S | ΔS | S | ΔS |
| | | | | | | Alternative S1A | | | | | | |
| 1 | 8.2 | 5.7 | 10.4 | 7.7 | 21.0 | 1.4 | 8.1 | 9.1 | 10.7 | 8.3 | 19.9 | 3.1 |
| 2 | 10.0 | 7.2 | 13.2 | 8.5 | 24.4 | 1.1 | 10.8 | 9.9 | 13.8 | 9.1 | 24.0 | 2.5 |
| 3 | 15.0 | 6.4 | 20.6 | 5.1 | 28.1 | 3.9 | 16.3 | 8.2 | 19.0 | 8.5 | 29.8 | 4.0 |
| 4 | 18.0 | 5.1 | 21.3 | 5.6 | 31.8 | 2.0 | 19.4 | 6.7 | 21.8 | 7.0 | 31.3 | 4.4 |
| 5 | 22.1 | 3.9 | 24.6 | 4.6 | 33.9 | 2.1 | 23.0 | 5.3 | 24.8 | 6.2 | 33.3 | 4.4 |
| | | | | | | Alternative S1B | | | | | | |
| 1 | 9.8 | 4.1 | 14.1 | 4.0 | 21.0 | 1.4 | 12.1 | 5.1 | 16.6 | 2.4 | 20.8 | 2.2 |
| 2 | 11.8 | 5.4 | 17.8 | 3.9 | 24.4 | 1.1 | 16.1 | 4.6 | 20.2 | 2.7 | 24.6 | 1.9 |
| 3 | 17.4 | 4.0 | 22.4 | 3.3 | 30.2 | 1.8 | 20.9 | 3.6 | 23.9 | 3.6 | 31.0 | 2.8 |
| 4 | 20.2 | 2.9 | 23.8 | 3.1 | 31.8 | 2.0 | 23.2 | 2.9 | 25.8 | 3.0 | 32.5 | 3.2 |
| 5 | 23.8 | 2.2 | 26.5 | 2.7 | 34.0 | 2.0 | 25.9 | 2.4 | 28.0 | 3.0 | 34.5 | 3.2 |
| | | | | | | Alternative S1C | | | | | | |
| 1 | 7.9 | 6.0 | 10.4 | 7.7 | 21.6 | 0.8 | 7.9 | 9.3 | 10.4 | 8.6 | 22.2 | 0.8 |
| 2 | 9.5 | 7.7 | 13.1 | 8.6 | 24.8 | 0.7 | 10.4 | 10.3 | 13.2 | 9.7 | 25.9 | 0.6 |
| 3 | 14.2 | 7.2 | 18.8 | 6.9 | 31.0 | 1.0 | 15.8 | 8.7 | 18.7 | 8.8 | 32.8 | 1.0 |
| 4 | 17.3 | 5.8 | 21.3 | 5.6 | 32.6 | 1.2 | 18.8 | 7.3 | 21.9 | 6.9 | 34.6 | 1.1 |
| 5 | 21.6 | 4.4 | 24.6 | 4.6 | 34.8 | 1.2 | 22.5 | 5.8 | 24.8 | 6.2 | 36.6 | 1.1 |
| | | | | | | Alternative S1D | | | | | | |
| 1 | 7.8 | 6.1 | 9.5 | 8.6 | 20.7 | 1.7 | 7.7 | 9.5 | 9.7 | 9.3 | 19.6 | 3/4 |
| 2 | 9.3 | 7.9 | 12.1 | 9.6 | 24.2 | 1.3 | 10.2 | 10.5 | 12.1 | 10.8 | 23.7 | 2.8 |
| 3 | 13.9 | 7.5 | 18.0 | 7.7 | 29.8 | 2.2 | 13.5 | 17.9 | 17.9 | 9.6 | 21.4 | 4.4 |
| 4 | 17.1 | 6.0 | 20.5 | 6.4 | 31.3 | 2.5 | 18.5 | 20.9 | 20.9 | 7.9 | 30.7 | 5.0 |
| 5 | 21.4 | 4.6 | 24.0 | 5.2 | 33.6 | 2.4 | 22.2 | 24.1 | 24.1 | 6.9 | 32.9 | 4.8 |

1/ 1970 hydrology

2/ 2020 limited growth hydrology

3/ Stage in feet

4/ Stage without minus stage with alternative

Index Stations

1 Fifth Street
2 Seventh Street
3 Chester High School
4 Kerlin Street
5 Toby Farms

| S1A, S1B, S1C, S1D | COMBINATION OF DRY RESERVOIRS |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Varies at different locations

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** See HYDRAULIC EFFECTS on previous page

**DAMAGE LEVELS** S1A eliminates $10,971,000 of $13,243,000 in damages; S1B eliminates $7,254,000; S1C eliminates $10,909,000; S1D eliminates $11,476,000.

## ECONOMICS

| | S1A | S1B | S1C | S1D |
|---|---|---|---|---|
| PROJECT COST (TOTAL) | $11,804,000 | $18,311,000 | $23,791,000 | $26,953,000 |
| construction | 4,787,000 | 6,230,000 | 7,597,000 | 9,307,000 |
| lands and relocation | 6,303,000 | 11,550,000 | 15,373,000 | 16,563,000 |
| recreation | 714,000 | 531,000 | 921,000 | 1,083,000 |
| AVERAGE ANNUAL COSTS | $ 822,000 | $ 1,242,000 | $ 1,595,800 | $ 1,829,900 |
| interest and amortization | 762,000 | 1,182,000 | 1,535,800 | 1,739,900 |
| operation and maintenance | 60,000 | 60,000 | 60,000 | 90,000 |
| AVERAGE ANNUAL BENEFITS | $ 1,558,800 | $ 1,104,300 | $ 1,848,500 | $ 2,133,300 |
| flood control | 461,800 | 319,300 | 472,500 | 504,300 |
| recreation | 1,097,000* | 785,000* | 1,376,000* | 1,629,000* |
| BENEFIT / COST RATIO | | | | |
| FLOOD CONTROL ONLY | 0.60 | 0.26 | 0.31 | 0.29 |
| FLOOD CONTROL & RECREATION | 1.9* | 0.89* | 1.2* | 1.2* |

* Recreation benefits result from complete utilization of project lands. However they can not be used to justify the flood control project.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of most flood related problems.
- Reduction of psychological stresses from the threat of floods.
- Increase opportunity for recreation, conservation and natural development.
- Alteration of the natural environment at the reservoir sites and at the sites used to supply materials for construction.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 67%, 46%, 68%, and 73% reduction (for S1A, S1B, S1C, and S1D respectively) of the $696,000 in annual damages in the areas downstream of the reservoirs.
- Annual maintenance cost for these reservoirs.
- Reduction of restrictions to economic growth in business and taxable property located in part of the areas protected by these reservoirs.

## CONCLUSIONS

These alternatives can provide some protection. They can not be economically justified as flood control projects and have major adverse environmental effects. They were eliminated from further consideration.

| S2A, S2B | COMBINATION OF DRY RESERVOIRS, BRIDGE AND CHANNEL MODIFICATIONS |
|---|---|

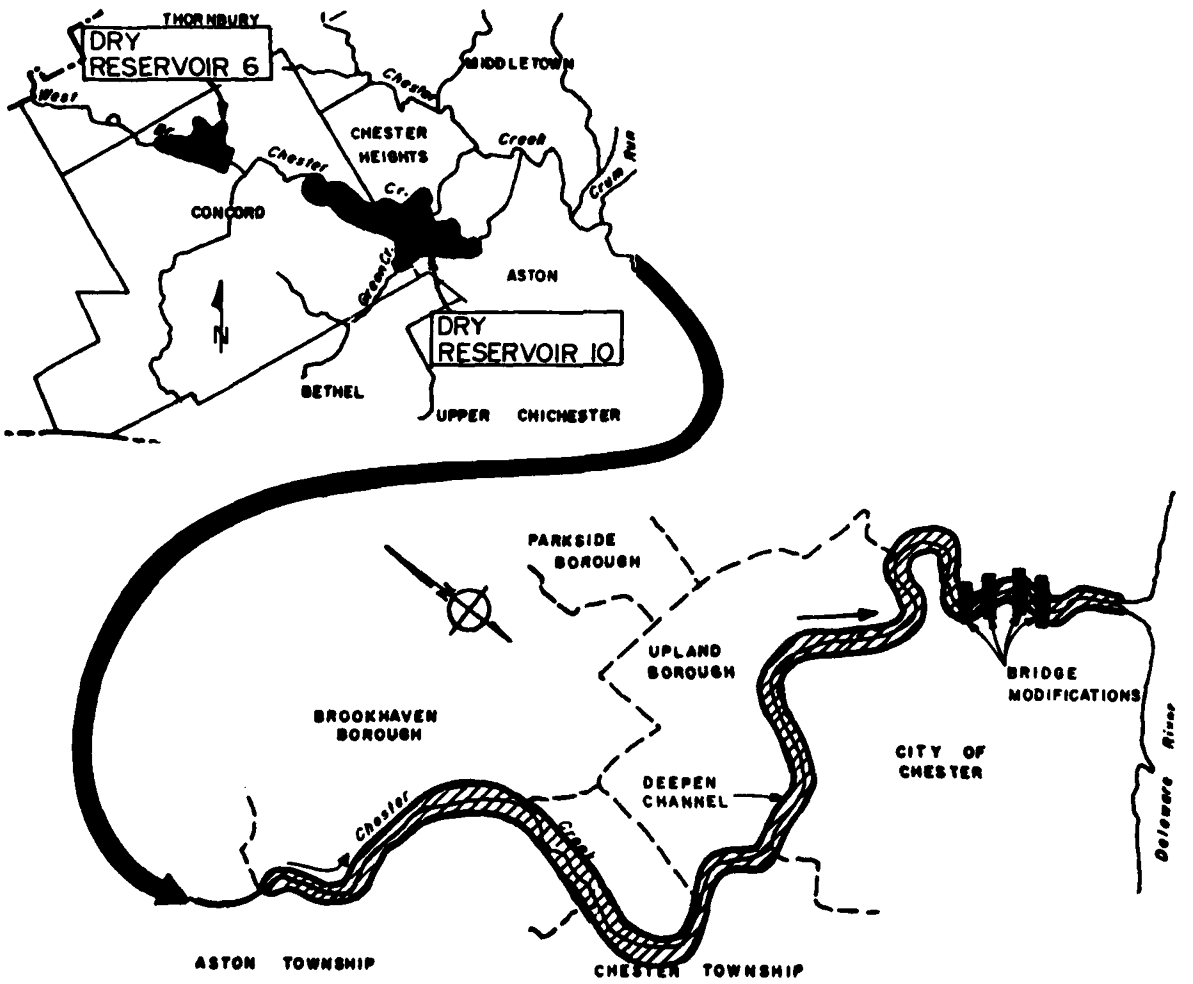
## DESCRIPTION

**PLAN** System S2A combines dry reservoir plans R6 and R10 with the replacement of the 9th Street bridge. System S2B combines R6 and R10 with channel (27,600 feet) and bridge modifications. The channel would be deepened 4 feet; bridges at 5th, 7th and 9th Sts. would be replaced; and 6th St. bridge removed. The reservoirs would require relocation of 2-1/2 miles of road & 21 buildings. During non-flood flows the dry reservoirs would be used for recreation. Maintenance dredging of the channel would be required every 5 years. Similar plans with various bridge modifications were also investigated but they performed less efficiently than S2A & S2B.

**LOCATION** Aston Township, Brookhaven Borough, Chester Heights Borough, Concord Township, Chester Township, City of Chester, Upland Borough

**PROJECT LIMITS** S2A and S2B - Reservoir sites; S2A - 9th Street Bridge; City of Chester; and S2B - Chester Creek from Dutton Mill Road to the Delaware River

**PROTECTION LIMITS** Dam Site R6 to the Delaware River



| S2A, S2B | COMBINATION OF DRY RESERVOIRS, BRIDGE AND CHANNEL MODIFICATIONS |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Varies at different locations

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** S2A reduces by 4-1/2 - 8-1/2 feet the flooding along The Creek which ranges up to 18 feet above the bank; and S2B reduces 5-10 feet.

**DAMAGE LEVELS** S2A eliminates $11,038,000 of the $13,243,000 in damages; and S2B eliminates $11,320,000.

## ECONOMICS

| | S2A | S2B |
|---|---|---|
| PROJECT COST (TOTAL) | $12,212,000 | $15,722,000 |
| construction | 5,195,000 | 8,705,000 |
| lands and relocation | 6,303,000 | 6,303,000 |
| recreation | 714,000 | 714,000 |
| AVERAGE ANNUAL COSTS (TOTAL) | $ 848,300 | $ 1,081,400 |
| interest and amortization | 788,300 | 1,014,900 |
| operation and maintenance | 60,000 | 66,500 |
| AVERAGE ANNUAL BENEFITS (TOTAL) | $ 1,568,000 | $ 1,592,300 |
| flood control | 471,000 | 495,300 |
| recreation | 1,097,000* | 1,097,000* |
| BENEFIT / COST RATIO | | |
| FLOOD CONTROL ONLY | 0.59 | 0.48 |
| FLOOD CONTROL & RECREATION | 1.8* | 1.5* |

* Recreation benefits result from complete utilization of project lands. However, they can not be used to justify the flood control project.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of most flood related problems.
- Reduction of psychological stresses from the threat of floods.
- Reduction in the deterioration of existing flood plain structures.
- Increase opportunity for recreation, conservation and natural development.
- Alteration of the natural environment at the reservoir sites and at the sites used to supply materials for construction.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 68% and 72% (S2A and S2B, respectively) of the $696,000 in annual flood damages in the area downstream of the reservoirs.
- Annual maintenance costs for the reservoirs and bridge.
- Improvement in the economic growth of business and taxable property located in the area protected by this alternative.

## CONCLUSIONS

These alternatives can provide some protection. They can not be economically justified as flood control projects and have major adverse environmental effects. They were eliminated from further consideration.

| S3B | CHANNEL REALIGNMENT AND EXCAVATION<br>DELAWARE RIVER TO DUTTON MILL ROAD |
|---|---|

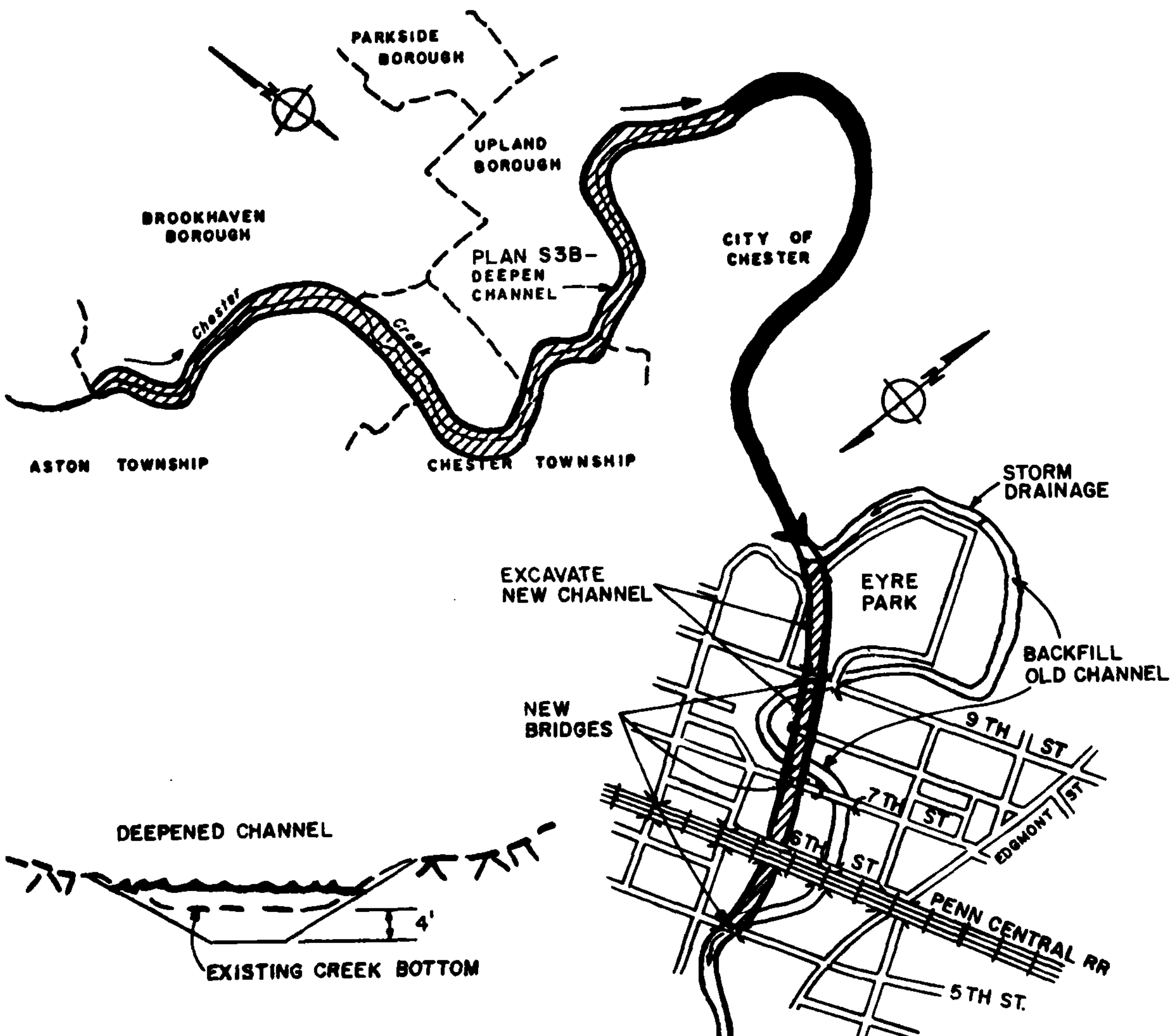
# DESCRIPTION

**PLAN** Plan S3B includes 25,300 feet of channel deepening from the Delaware River to Dutton Mill Road; a 2400-foot channel realignment and bridge modification at 5th, 7th, and 9th Streets. Most of the channel would be a natural banked channel, 4 feet below the existing bottom. The channel realignment would be a riprapped (rock) channel with a 50-foot bottom width and a 140-foot top width. The existing channel would be filled in except near Interstate 95 where it would be used to carry storm drainage. Maintenance dredging, a local responsibility, would be required at 5 year intervals.

**LOCATION** City of Chester, Borough of Upland, Chester Township, Brookhaven Borough, Aston Township

**PROJECT LIMITS** Delaware River to Dutton Mill Road

**PROTECTION LIMITS** Delaware River to Dutton Mill Road



| S3B | CHANNEL REALIGNMENT AND EXCAVATION<br>DELAWARE RIVER TO DUTTON MILL ROAD |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Varies at different locations

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** Reduces by up to 2-1/2 to 8-1/2 feet the flooding along the Creek which ranges up to 18 feet above the bank

**DAMAGE LEVELS** Eliminates $6,128,000 of the $10,693,000 in damages.

## ECONOMICS

| | |
|---|---|
| **PROJECT COST (TOTAL)** | $5,878,000 |
| construction | 5,567,000 |
| lands and relocation | 311,000 |
| recreation | * |
| **AVERAGE ANNUAL COSTS (TOTAL)** | $ 386,000 |
| interest and amortization | 379,500 |
| operation and maintenance | 6,500 |
| **AVERAGE ANNUAL BENEFITS (TOTAL)** | $ 268,000 |
| flood control | 268,000 |
| recreation | * |
| **BENEFIT / COST RATIO** | |
| FLOOD CONTROL ONLY | 0.69 |
| FLOOD CONTROL & RECREATION | * |

* Not estimated since recreation facilities can not be provided by project.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood related problems for large areas.
- Disruption of flora and fauna by channel excavation.
- Alteration to the natural environment by the disposal of excavated materials for both project construction and maintenance dredging.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 58% reduction of the $465,000 in annual damages in the areas protected by these alternatives.
- Annual maintenance cost for the alternative.
- Reduction in restrictions to economic growth in business and taxable property located in flood plain fringe areas.

## CONCLUSIONS

This alternatives can provide some protection. It can not be economically justified. It was eliminated from further consideration.

| S4A, S4B, S4C | COMBINATION OF DRY RESERVOIR, BRIDGE AND CHANNEL MODIFICATIONS AND CHANNEL REALIGNMENT |
|---|---|

# DESCRIPTION

**PLAN** This system combines a 427 acre dry reservoir with channel realignment for 2300 feet in Chester City. The earth and rock dam would impound floodwater and require road relocations, levee construction, and purchase of 16 buildings. During normal flow conditions the area would be maintained by local sponsors for hiking, picnicking, and other recreational activities. Bridges at 5th and 9th Sts. would be removed and new bridges constructed at 5th, 7th and 9th Sts. Downstream of Eyre Park the old channel would be backfilled. The new channel would require building evacuations and maintenance dredging would be needed every 5 years.

**LOCATION** Aston Township, Brookhaven Borough, Chester Heights Borough, Chester Township, City of Chester, Concord Township, Upland Borough

**PROJECT LIMITS** S4A, S4B and S4C - reservoir site; S4A - Eyre Park to 5th Street, City of Chester; S4B - bridges. City of Chester; S4C - Dutton Mill Road to the Delaware.

**PROTECTION LIMITS** Dam site to the Delaware River

HYDRAULIC EFFECTS

| Index Station | EXISTING CONDITIONS 1/ | | | | | | FUTURE CONDITIONS 2/ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50-Year | | 100-Year | | SPF | | 50-Year | | 100-Year | | SPF | |
| | S 3/ | ΔS 4/ | S | ΔS | S | ΔS | S | ΔS | S | ΔS | S | ΔS |
| | | | | | | | Alternative S4A | | | | | |
| 1 | 9.4 | 4.3 | 11.2 | 6.9 | 20.2 | 2.2 | 9.2 | 8.0 | 11.0 | 8.0 | 19.8 | 3.2 |
| 2 | 10.1 | 7.1 | 13.0 | 8.7 | 23.5 | 2.0 | 10.4 | 10.3 | 13.1 | 9.8 | 23.8 | 2.7 |
| 3 | 11.7 | 9.7 | 14.1 | 11.6 | 23.5 | 8.5 | 12.4 | 12.1 | 14.0 | 13.5 | 23.5 | 10.3 |
| 4 | 17.5 | 5.6 | 21.1 | 5.7 | 27.2 | 6.6 | 18.8 | 7.3 | 21.0 | 7.8 | 27.2 | 8.5 |
| 5 | 22.4 | 3.6 | 25.4 | 3.8 | 31.7 | 4.3 | 22.9 | 5.4 | 25.3 | 5.7 | 31.6 | 6.1 |
| | | | | | | | Alternative S4B | | | | | |
| 1 | 9.6 | 4.3 | 11.5 | 6.6 | 21.5 | 0.9 | 9.2 | 8.0 | 11.5 | 7.5 | 20.9 | 2.1 |
| 2 | 10.3 | 6.9 | 14.3 | 7.4 | 25.1 | 0.4 | 11.1 | 9.6 | 14.4 | 8.5 | 25.3 | 1.2 |
| 3 | 16.1 | 5.3 | 19.5 | 6.2 | 29.9 | 2.1 | 16.7 | 7.8 | 21.1 | 6.4 | 30.0 | 3.8 |
| 4 | 19.9 | 3.2 | 22.9 | 4.0 | 31.7 | 2.1 | 19.7 | 6.4 | 22.7 | 6.1 | 31.9 | 3.8 |
| 5 | 22.6 | 3.4 | 25.8 | 3.4 | 34.3 | 1.7 | 23.2 | 5.1 | 25.8 | 5.2 | 34.4 | 3.3 |
| | | | | | | | Alternative S4C | | | | | |
| 1 | 9.5 | 4.4 | 11.0 | 7.1 | 21.7 | 0.7 | 9.1 | 8.1 | 10.8 | 8.2 | 21.2 | 1.8 |
| 2 | 10.1 | 7.1 | 12.6 | 9.1 | 23.2 | 2.3 | 10.4 | 10.3 | 12.2 | 10.7 | 23.5 | 3.0 |
| 3 | 16.1 | 5.3 | 19.1 | 6.6 | 30.1 | 1.9 | 16.7 | 7.8 | 19.1 | 8.4 | 30.6 | 3.2 |
| 4 | 19.3 | 3.8 | 22.1 | 4.8 | 31.6 | 2.2 | 19.2 | 6.9 | 22.0 | 6.8 | 31.8 | 3.9 |
| 5 | 22.0 | 4.0 | 25.2 | 4.0 | 34.1 | 1.9 | 22.6 | 5.7 | 25.1 | 5.9 | 34.2 | 3.5 |

1/ 1970 hydrology

2/ 2020 limited growth hydrology

3/ Stage in feet

4/ Stage without minus stage with alternative

Index Stations

1 Fifth Street
2 Seventh Street
3 Chester High School
4 Kerlin Street
5 Toby Farms

| S4A, S4B, S4C | COMBINATION OF DRY RESERVOIR, BRIDGE AND CHANNEL MODIFICATIONS AND CHANNEL REALIGNMENT |
|---|---|

## PHYSICAL PERFORMANCE

**LEVEL OF PROTECTION** Varies at different locations

**EFFECT ON THE 100 YEAR FLOOD**

**FLOODING LEVELS** See HYDRAULIC EFFECTS on previous page

**DAMAGE LEVELS** S4A eliminates $9,904,000 of $13,083,000 in damages; S4B eliminates $9,078,000; and S4C eliminates $9,590,000

## ECONOMICS

| | S4A | S4B | S4C |
|---|---|---|---|
| PROJECT COST (TOTAL) | $12,250,000 | $9,934,000 | $12,561,000 |
| construction | 6,382,000 | 4,369,000 | 6,996,000 |
| lands and relocation | 5,316,000 | 5,013,000 | 5,013,000 |
| recreation | 522,000 | 522,000 | 522,000 |
| AVERAGE ANNUAL COSTS (TOTAL) | $ 821,800 | $ 671,300 | $ 847,400 |
| interest and amortization | 720,800 | 641,300 | 810,900 |
| operation and maintenance | 31,000 | 30,000 | 36,500 |
| AVERAGE ANNUAL BENEFITS (TOTAL) | $ 1,485,200 | $ 1,425,900 | $ 1,450,700 |
| flood control | 641,200 | 581,900 | 606,700* |
| recreation | 844,000* | 844,000* | 844,000 |
| BENEFIT/COST RATIO | | | |
| FLOOD CONTROL ONLY | 0.75 | 0.92 | 0.75 |
| FLOOD CONTROL & RECREATION | 1.8* | 2.1* | 1.7* |

* Recreation benefits result from complete utilization of project lands. However, they can not be used to justify the flood control project.

## SOCIAL / ENVIRONMENTAL EFFECTS (major)

- Reduction of flood realted problems for large areas.
- Reduction of psychological stresses from the threat of floods.
- Reduction in the deterioration of existing flood plain structures.
- Increase opportunity for recreation, conservation and natural development.
- Alteration to the natural environment at the project sites, at the sites used to supply materials for construction and channel excavation material disposal areas.

## REGIONAL / ECONOMIC EFFECTS (major)

- A 92%, 84% and 87% reduction (for S4A, S4B, and S4C, respectively) of the $696,000 in annual damages in the area downstream of the reservoir.
- Annual maintenance costs for the alternative.
- Improvement in the economic growth of business and taxable property located in the flood plain.

## CONCLUSIONS

These alternatives can provide some protection and based on preliminary work appear to have potential for economic justification. However, neither Delaware Co. nor the affected local municipalities provided sponsorship and it was eliminated from further consideration.

## INSTITUTIONAL STUDIES

66. As a result of technical, economic and socio-environmental analyses and investigations, twelve plans were recommended for further consideration. The implementability of these twelve were tested. These plans were presented to all responsible local governments and agencies, special interest groups, and the general public. Meetings were held with each community where projects might be located as well as with County and Congressional representatives.

67. A workshop meeting was held with Chester Township officials and Toby Farms residents. Chester Township officials held their own meeting with residents of Toby Farms. These plans were presented at a 15 February 1977 Delaware County Planning Commission workshop meeting for all communities in the Basin. A public meeting was held on 27 April 1977.

68. The Council of Delaware County adopted a resolution stating that they supported two plans in the City of Chester, channel realignment and channel widening, as well as the flood proofing and flood forecasting, warning, and preparedness plans. While supporting flood proofing and flood forecasting, warning, and preparedness plans, Delaware County did not indicate an intent to provide local assurances. They requested additional information on the non-structural plans for local implementation.

69. The Delaware County Council considered the input of affected citizens and municipalities including statements made at the Corps' public meeting and workshops. Chester Heights Borough and Concord Township passed resolutions opposing any plans which included dry reservoirs in their communities. Chester Township passed a resolution not supporting the levee plans being considered for Toby Farms.

70. At least one meeting was held with officials of each municipality. None of the municipalities were able to provide local assurances. All felt that Delaware County should be a project sponsor. Chester County representatives were contacted regarding flood proofing and flood forecasting, warning, and preparedness plans, but were not interested in supporting these plans in Chester County.

71. A summary of the results of coordination for local assurances is presented in Table D-6. Local sponsorship was received only for two channel modifications in the City of Chester, L6G and S3A; therefore, these were the only plans considered further for Federal implementation.

# TABLE D-6
## RESULTS OF COORDINATION FOR LOCAL ASSURANCES

| Alternative Plans which were "Tentatively Recommended" For Further Study | | | |
|---|---|---|---|
| **Plan Number** | **Type of Plan** | **Plan Location** | **Responses to Request for Local Assurances** |
| L6G | Bridge Modification Channel Widening | City of Chester | Delaware County provided local assurances. Once it is determined which plan (L6G or S3A) is economically & environmentally most acceptable, the County will provide lands, easements and rights-of-way; and operation and maintenance of the completed project. |
| S3A | Channel Realignment | City of Chester | |
| FW1 | Flood Forecasting, Warning, & Preparedness Planning | Chester Creek Basin-entire basin | No assurances were received from Delaware or Chester Counties or any municipalities for these plans. Delaware County has indicated that they might implement these plans, if they are feasible. |
| FP1 | Flood Proofing | Chester Creek Basin-where applicable | |
| | | | Delaware County resolved the remainder of the plans as follows: |
| FI1 | Flood Insurance | Chester Creek Basin all flood plains | FI1 - All eligible residents and municipalities were urged to participate in the National Flood Insurance Program and pledged to continue to assist local government in making use of this important program |
| L8A | Levee - 100 Year Flood Protection | Toby Farms, Chester Township | L8A & L8B - Neither Chester Township nor Delaware County provided assurances for these plans. Chester Township adopted a resolution not supporting L8A and L8B. |
| L8B | Levee - Standard Project Flood Protection | Toby Farms, Chester Township | |
| L10A | Levees, Floodwalls, & Bridge Modifications-100-Year Flood Protection | Lenni | L10A & L10B - Neither Delaware County nor Aston and Middletown Townships provided local sponsorship for these plans. |
| L10B | Levees, Floodwalls, & Bridge Modifications-Standard Project Flood | Lenni | |
| S4A | Combination of Dry Reservoir & Channel Realignment | Aston, Chester Heights, City of Chester, Concord | S4A, S4B & S4C - Neither Delaware County nor the municipalities in which the projects were located provided local sponsorship for these plans. Chester Heights Borough and Concord Township adopted resolutions opposing plans S4A, B and C. |
| S4B | Combination of Dry Reservoir & Bridge Modifications | Aston, Chester Heights, City of Chester, Concord | |
| S4C | Combination of Dry Reservoir, Bridge & Channel Modifications | Aston, Brookhaven, Chester Heights, Chester Township, City of Chester, Concord, Upland | |

## PLANS CONSIDERED FURTHER

72. More detailed Stage II investigations of Plan L6G and S3A were approached at an increasing level of detail on items which were critical to project justification. This cautious approach was taken because investigations to this point did not indicate high levels of economic feasibility. As a result of this further analysis, an alignment variation (Plan S3Ab) of Plans S3A was also developed. However, in more detailed studies all these plans (L6G, S3A, and S3Ab) were not economically justified. Information on these plans and findings is presented in the following paragraphs.

73. The economic analyses of these plans were based on a January 1978 price level, a discount rate of 6-5/8%, and an economic life of 50 years. Project benefits were computed for flood control, advance replacement of bridges and employing previously unemployed workers. The flood control benefits were inundation reduction benefits of existing flood prone structures and for future affluence of residential contents and urbanization. Affluence benefits are the reduction in flood damages to increases in the value of residential contents that would occur in the absence of a project. Future benefits for urbanization are claimed for reductions in the effects of increased flood levels due to upstream development.

74. The benefit analyses were refined and updated since the plans were originally analized and presented to local interests. Adjustments were made to inundation reduction and urbanization benefits to reflect physical changes in the flood plain, such as recently demolished structures or demolitions planned in the immediate future. Twenty-three homes and 15 businesses were deducted from the benefit calculations.

75. Additional benefits can be realized due to advance replacement of bridges. By replacing existing bridges the flood control project, in effect, extends the period during which existing bridge's benefits can be realized. The existing bridge benefits are at least equal to their costs. Based on an assumption of 1985 as the base year, when a project is first operational, the lives of the bridges would be extended as follows: Fifth Street by 18 years; Sixth Street by 21 years; Seventh Street by 18 years; and Ninth Street by 33 years.

76. NED employment benefits can also be realized. The City of Chester lies in the Philadelphia Standard Metropolitan Statistical Area (SMSA), which has been declared an area of substantial unemployment by the Manpower Administration of the U.S. Department of Labor. The unemployment rate for the Philadelphia SMSA was 6.4 percent in December 1977. Delaware County is designated as a Title IV Redevelopment Area under the Public Works

and Economic Development Act of 1965, as amended. Wages to workers previously unemployed or underemployed who are directly employed in project construction are creditable to the NED account. Labor costs for the three plans were estimated to vary between 25 to 30 percent of the construction costs. Construction costs are the project first cost less real estate, engineering and design, and supervision and administration. Labor costs credited to the NED account include wages to both skilled and unskilled workers. The construction of any of the projects would provide the equivalent of about 50 full-time workers for about one year.

77. A more detailed presentation of benefits is found in Section H, Benefit Analysis.

## PLAN L6G

78. This local protection plan involves the replacement of three bridges and about 1700 feet of stream channel from below the Fifth Street Bridge to above the Seventh Street Bridge in the City of Chester. This plan could reduce 100-year flood stages of 2 to 18 feet by 1 to 5-1/2 feet. It would reduce average annual damages of $598,800 by about 23%. It was initially intended that this plan would be part of a total Basin plan consisting of dry reservoirs, channels, or flood proofing. An overall high level of protection would be provided. However, even though these other types of measures did not receive local sponsorship, this concept was considered further at the direct request of Delaware County.

79. TECHNICAL ANALYSIS AND DESIGN. The main features of plan L6G are shown on Plate D-3. Plan L6G involves replacement of the bridges at Fifth, Sixth, and Seventh Street in conjunction with channel widening for a distance of 1,680 feet. The channel would be widened to a minimum bottom width of 100 feet with excavated sideslopes of 2 (horizontal) and 1 (vertical). The Creek banks would be grassed and a seeded and landscaped barrier would be placed along the banks. The widened channel will require longer bridge spans (180 feet) at Fifth and Seventh Streets and transitions to about a 120 feet top width where the channel width is limited in the area of the Sixth Street Bridge and Amtrak viaduct. The three bridges and approaches would be raised to allow passage of a 100-year flood without backup. The transition upstream of Sixth Street would consist of a 70 feet long concrete wingwall on the southern bank. Concrete walls downstream of the viaduct would form the transition to the wider, trapezoidal channel downstream. The bridges at Second and Third Street are planned for replacement with a single bridge through construction of U.S. Highway 13 (PA Route 291). Depending on funding, this construction should be completed sometime after 1982. Replacement of the Bridge as part of this flood control

plan is therefore unnecessary, since it would be high enough to allow passage of a 100-year flood without backup. About 3.2 acres of land would be required to widen the channel. Maintenance dredging would be required every five years.

80. Several changes were made in this plan since it was originally presented to local interests. Previously no new bridge was needed at Sixth Street. The City of Chester has now identified this street as a necessary part of their new one-way traffic circulation system for the Central Business District; therefore, the bridge must be replaced. Previous work on Seventh Street was for an additional span over the widened channel. However, by providing a new, higher bridge and road approaches at Seventh Street, along with Sixth and Fifth Streets, a 100-year flow can be passed without constriction. Transitions upstream of Sixth Street and downstream of the Amtrak viaduct were added to improve hydraulic performance. Additional costs arose for excavating through asphalt, rock and random materials.

81. HYDRAULIC PERFORMANCE. This provides some protection to damage reaches 1 through 12 by reducing stages over a range of flows. These areas are represented by Index Stations 1 through 5 on Table D-7. This table shows the stage reductions due to this plan. As can be seen the stage reduction is relatively small when compared to the total depth of over bank flooding.

82. COSTS. The estimated first cost and annual costs are $2,886,000, and $206,700. A breakdown by major items is shown below.

PLAN L6G

CONSTRUCTION COST

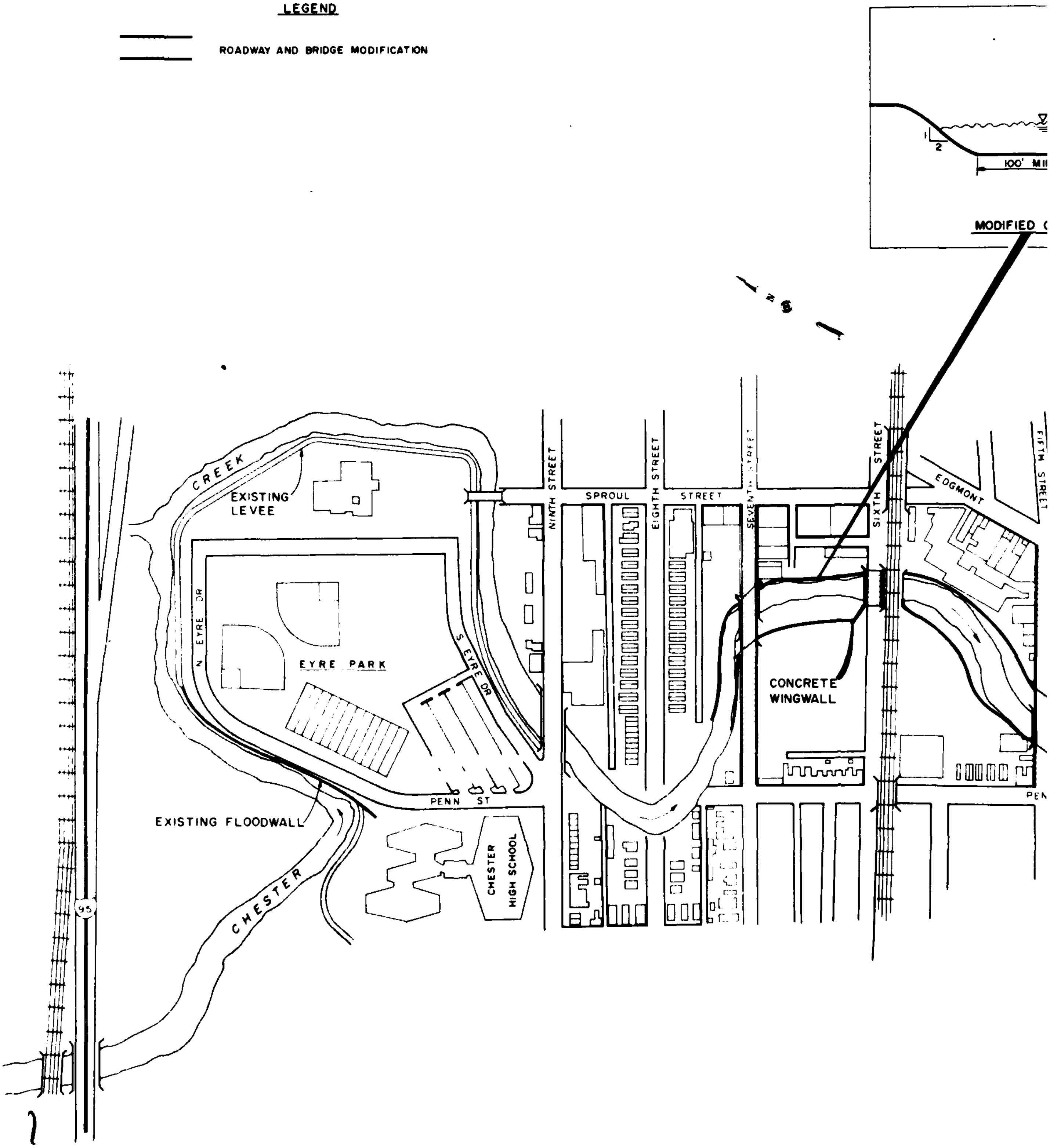
| Item | Cost |
|---|---|
| Channel and Transition | $ 527,000 |
| Bridges and Roads | 1,463,000 |
| Contigencies @ 25% | 497,000 |
| Real Estate | 22,000 |
| Engineering & Design, Supervision & Administration @ 15% | 377,000 |
| Total First Cost | $2,886,000 |

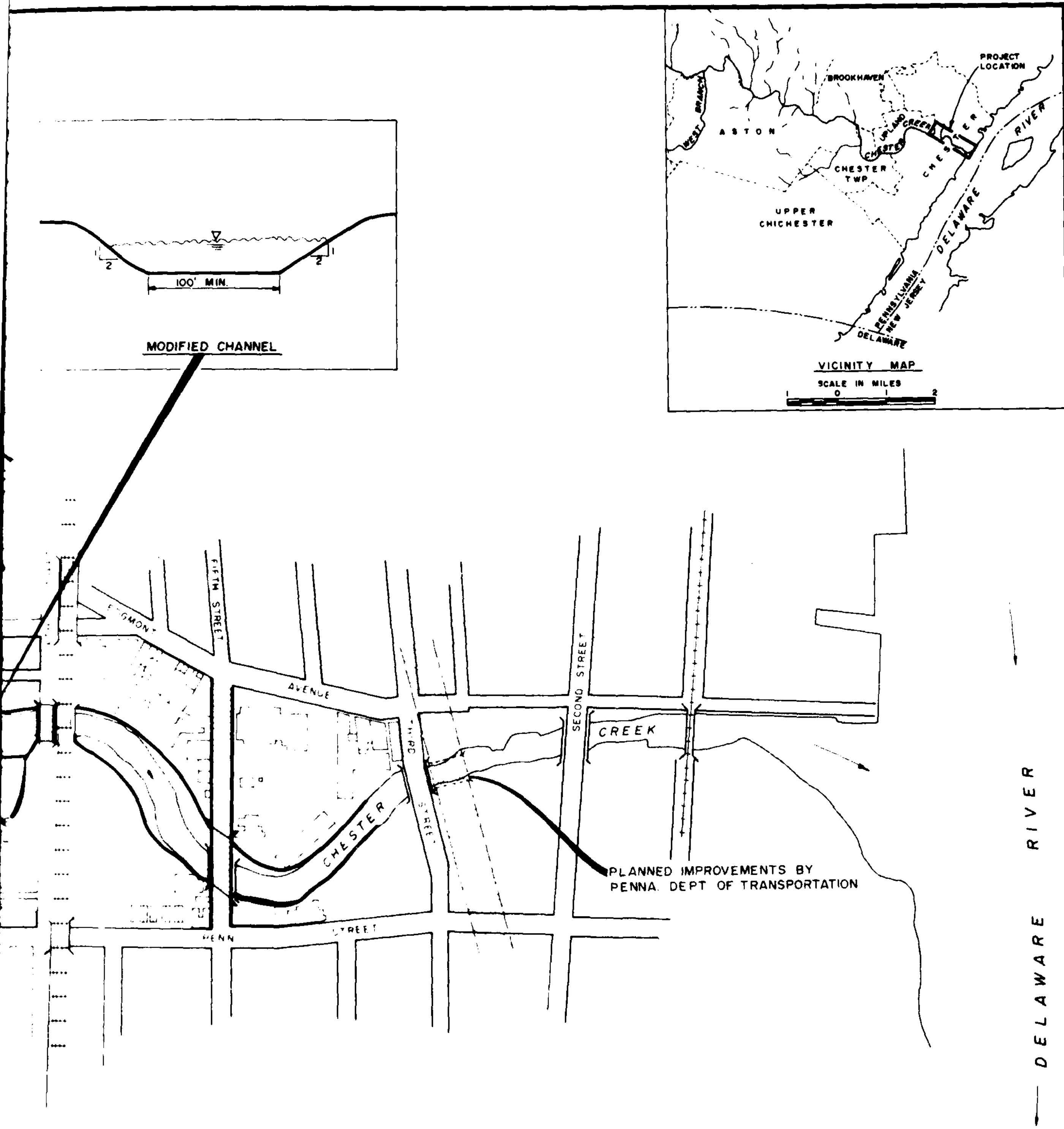
AVERAGE ANNUAL COST

| | |
|---|---|
| Project Cost Amortized (50-Years, 6-5/8%) | $ 199,300 |
| Annual Operation and Maintenance | 7,400 |
| Total Annual Cost | $ 206,700 |

LEGEND

ROADWAY AND BRIDGE MODIFICATION






CHESTER CREEK BASIN, PENNSYLVANIA

**CHANNEL AND BRIDGE MODIFICATIONS**
**PLAN L6G**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

2

PLATE D-3

TABLE D-7
STAGE REDUCTIONS
PLAN L6G 1/

| Index Sta. | Location | SPF Exist. | SPF L6G | SPF △ | 100-Year Exist. | 100-Year L6G | 100-Year △ | 50-Year Exist. | 50-Year L6G | 50-Year △ | 10-Year Exist. | 10-Year L6G | 10-Year △ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5th Street-Station 22+10 | 22.4 | 22.6 | -0.2 | 18.1 | 15.9 | +2.2 | 13.9 | 12.3 | +1.6 | 7.5 | 8.0 | -0.5 |
| 2 | 7th Street-Station 33+80 | 25.5 | 23.0 | +2.5 | 21.7 | 16.3 | +5.4 | 17.2 | 12.5 | +4.7 | 8.8 | 8.3 | +0.5 |
| 3 | Chester High School-Station 78+90 | 32.0 | 30.9 | +1.1 | 25.7 | 22.9 | +2.8 | 21.4 | 19.5 | +1.9 | 13.2 | 13.0 | -0.2 |
| 4 | Kerlin Street-Station 108+90 | 33.8 | 32.3 | +1.5 | 26.9 | 24.9 | +2.0 | 23.1 | 22.2 | +0.9 | 16.2 | 16.2 | 0 |
| 5 | Toby Farms-Station 176+100 | 36.0 | 34.6 | +1.4 | 29.2 | 27.9 | +1.3 | 26.0 | 25.4 | +0.6 | 20.4 | 20.4 | 0 |

1/ Stage reductions are not displayed for Index Station 6 because they were insignificant and damages were reduced by only 1% in damage reach 12.

83. BENEFITS. Existing inundation benefits are estimated to be $109,100 annually. Future annual benefits are $27,200 with total inundation benefits of $136,300. Damage reduction, in percent, by damage reach are presented in Table D-8. In the City of Chester these reductions range from 13 to 65 percent of average annual damages. Bridge replacement benefits of $7,500 annually were computed for the Fifth, Sixth and Seventh Street bridges. Unemployment benefits of $12,900 annually were computed with an estimated labor component of 25% of the total construction cost.

84. BENEFIT TO COST RATIOS. Benefit to cost ratios are displayed below. The existing benefit to cost ratio is 0.62 to 1.0. With future benefits, the ratio is 0.76 to 1.0.

PLAN L6G

| Benefit Conditions | Average Annual Benefits | Average Annual Cost | Benefit to Cost Ratio |
|---|---|---|---|
| Existing Inund. Reduct. | $109,100 | $206,700 | 0.53 |
| Existing Inund. Reduct.<br>Adv. Bridge Repl. | $116,600 | $206,700 | 0.56 |
| Existing Inund. Reduct.<br>Adv. Bridge Repl.<br>Employment | $129,500 | $206,700 | 0.62 |
| Existing Inund. Reduct.<br>Adv. Bridge Repl.<br>Employment<br>Affluence & Urbaniz. | $156,700 | $206,700 | 0.76 |

85. PLAN IMPACTS. The significant impacts of plan L6G are summaried in Table D-9 according to one of the following categories: National Economic Development, Environmental Impact, Regional Development, or Social Well-Being.

86. CONCLUSIONS. Plan L6G for bridge and channel modifications in the City of Chester was originally developed to remove bridge constrictions. The plan was intended to be combined with other plans to reduce flood levels and damages. By itself the flood stage reductions throughout the City were generally small compared to natural flood depths. The most favorable benefit to cost ratio is 0.76 to 1.0.

87. The plan's ability to solve the flooding problems is not significant. The impacts of construction are generally adverse but temporary with regard to the environment. This plan can not be considered for implementation by the Federal Government.

TABLE D-8
DAMAGE REDUCTION BY REACH
EXISTING AND FUTURE INUNDATION
PLAN L6G 1/

| Index Station | Damage Reach | Damage Reach Location | Existing Cond. EAAD ($x1000) | Residual EAAD ($x1000) | Percent Reduced 3/ |
|---|---|---|---|---|---|
| 1 | 1 | Delaware Riv. to 2nd St. | $ 7.56 | $ 5.63 | 26% |
| 1 | 2 | 2nd St. to 3rd St. | 18.08 | 12.96 | 28 |
| 1 | 3 | 3rd St. to 5th St. | 31.18 | 25.44 | 18 |
| 1,2 | 4 | 5th St. to 7th St. | 25.93 | 22.63 | 13 |
| 2 | 5 | 7th St to 9th St. | 65.93 | 23.00 | 65 |
| 3 | 6 | 9th St. to 10th St. | 50.08 | 34.99 | 30 |
| 3 | 7 | 10th St to I-95 | 11.47 | 8.18 | 29 |
| 4 | 8 | I-95 to Kerlin St. | 79.10 | 65.76 | 17 |
| 4 | 9 | Kerlin St. to Toby Farms | 134.42 | 102.50 | 24 |
| 5 | 10 | Toby Farms Area | 139.95 | 128.58 | 8 |
| 5 | 11 | Toby Farms to Dutton Mill Road | 11.61 | 9.60 | 17 |
| 6 | 12 | Dutton Mill Rd. to Knowlton Road | 23.50 | 23.25 | 1 |
| 7 to 10 | 13 to 18 | Knowlton Rd to Rt. 1 | | | 0 |
| | | TOTALS (ROUNDED) | $598,800 | $462,500 | 23% |

1/ January 1978 Price Level

2/ Existing Cond. EAAD - Residual EAAD = Percent Reduced
Existing Cond. EAAD

TABLE D-9
SIGNIFICANT EFFECT ASSESSMENTS
PLAN L6G

| EFFECTS OF PLAN | | ASSESSMENT DURATION 1/ | ASSESSMENT TYPE 2/ |
|---|---|---|---|
| National Economic Development | | | |
| Inundation reduction benefits (existing) = | $ 109,100 | P | B |
| Affluence and urbanization benefits = | 27,200 | P | B |
| Advance bridge replacement benefits = | 7,500 | T | B |
| Increased employment benefits = | 12,900 | T | B |
| First Cost = | 2,886,000 | P | A |
| O&M Cost = | 7,400 | P | A |
| Minor alteration of business patterns during construction | | T | A |
| Regional Development | | | |
| Increased employment during project construction and maintenance operations. | | T | B |
| Disruption of transportation during construction. | | T | A |
| Minor alteration of business patterns during construction. | | T | A |
| Increased output of goods and services in Basin. | | P | B |
| A 23% reduction of the $598,800 in annual damages in the areas protected. | | P | B |
| Environmental Impact | | | |
| Adverse effects on aquatic life during construction. | | T | A |
| Loss of natural bank vegetation during construction. | | T | A |
| Acoustic, aesthetic, and air quality degradation during project construction. | | T | A |
| Historic sites will continue to be flooded. | | P | A |
| No known archeological sites are in the project area. | | P | - |
| Alteration of natural environment by the disposal of excavated materials for project construction and maintenance. | | P | A |
| Social Well-Being | | | |
| Loss of transportation and utility servic during construction. | | T | A |
| No significant effect on recreation potential. | | P | - |
| Loss of parking facilities. | | P | A |
| Slight reduction of emergency losses and disruption of public services. | | P | B |

1/ Duration indicates if the effect is permanent (P) or temporary (T).
2/ Type indicates if the effect is beneficial (B), adverse (A), or no change (-).

## PLAN S3A

88. This local protection plan involves channel realignment and bridge modifications from Third Street to Eyre Park in the City of Chester. The plan could reduce 100-year flood stages of 2 to 18 feet by 2 to 5 feet. It would also reduce average annual damages of $599,000 by 35% in the protected areas. This plan reduces flood heights by increasing flow. Flow is increased by eliminating the many bends and constrictive bridge openings along Chester Creek in the City of Chester.

89. Although the level of protection provided by this plan is not high, it was considered further for several reasons. It was desired by local interests. It has potential to be combined with other measures, such as flood proofing or flood warning and preparedness, which could further reduce residual damages.

90. TECHNICAL ANALYSIS AND DESIGN. The main features of plan S3A are shown on Plate D-4. This plan involves a new channel alignment from Eyre Park to Third Street for a distance of about 2,900 feet. Beginning near Chester High School, the realignment bypasses the loop at Eyre Park and passes under Ninth Street at approximately the existing bridge location. From there it continues in a nearly straight line to the Third Street Bridge. The new trapezoidal channel would have a 50 foot bottom width with 2 (horizontal) and 1 (vertical) sideslopes. Channel excavation would be partially through rock, where bank protection would not be needed. Non-rock portions of the channel would be seeded upstream of Seventh Street and riprap lined downstream. The old channel would be backfilled for a distance of about 5,100 feet. In order to allow stormwater to drain naturally to the realigned Creek, the overbank areas would be filled and graded for distances of up to about 500 feet. These surfaces would then be seeded and landscaped.

91. New bridges over the realigned Creek would be necessary at Fifth, Sixth, Seventh, and Ninth Streets with the old bridges being demolished and replaced by highway section except at Ninth Street. The spans would average about 150 feet and the width maintained as existing. The new bridges will be at elevations which will pass the 100-year flood without backup. Bridges at Second and Third Street are planned for replacement by a single bridge through construction of U.S. Highway 13 (PA Route 291). Depending on funding, this construction should be completed sometime after 1982. Replacement of the Bridge as part of this flood control plan is not therefore necessary, since it would be high enough to allow passage of a 100-year flood without constriction.

92. Many modifications would be required at the new High School parking and athletic facilities. The concrete floodwall near the High School

would be removed for about 150 feet to allow passage of the new channel. Levees would be provided through Eyre Park on both sides of the channel. The existing channel downstream of the I-95 drainage culvert will be filled for a distance of about 2,000 feet and the existing levee removed. The pedestrian bridge at the end of Sproul Street would be demolished and a path provided. The existing levee along North Eyre Drive will be tied into the I-95 embankment and the slope of the existing Creek bed reversed to allow drainage to the realigned Creek. Since the realignment passes through the middle of the High School's new parking facilities, the lot would have to be relocated and new access off of Ninth Street provided to the parking lot, athletic fields, and YMCA. A 160 foot long footbridge would be provided to allow access from the High School to the parking lot and fields. Several utilities including sanitary and storm sewers, water lines, and utility poles would have to be relocated in Eyre Park. In addition, further work may show the need for relocation of the new practice football field.

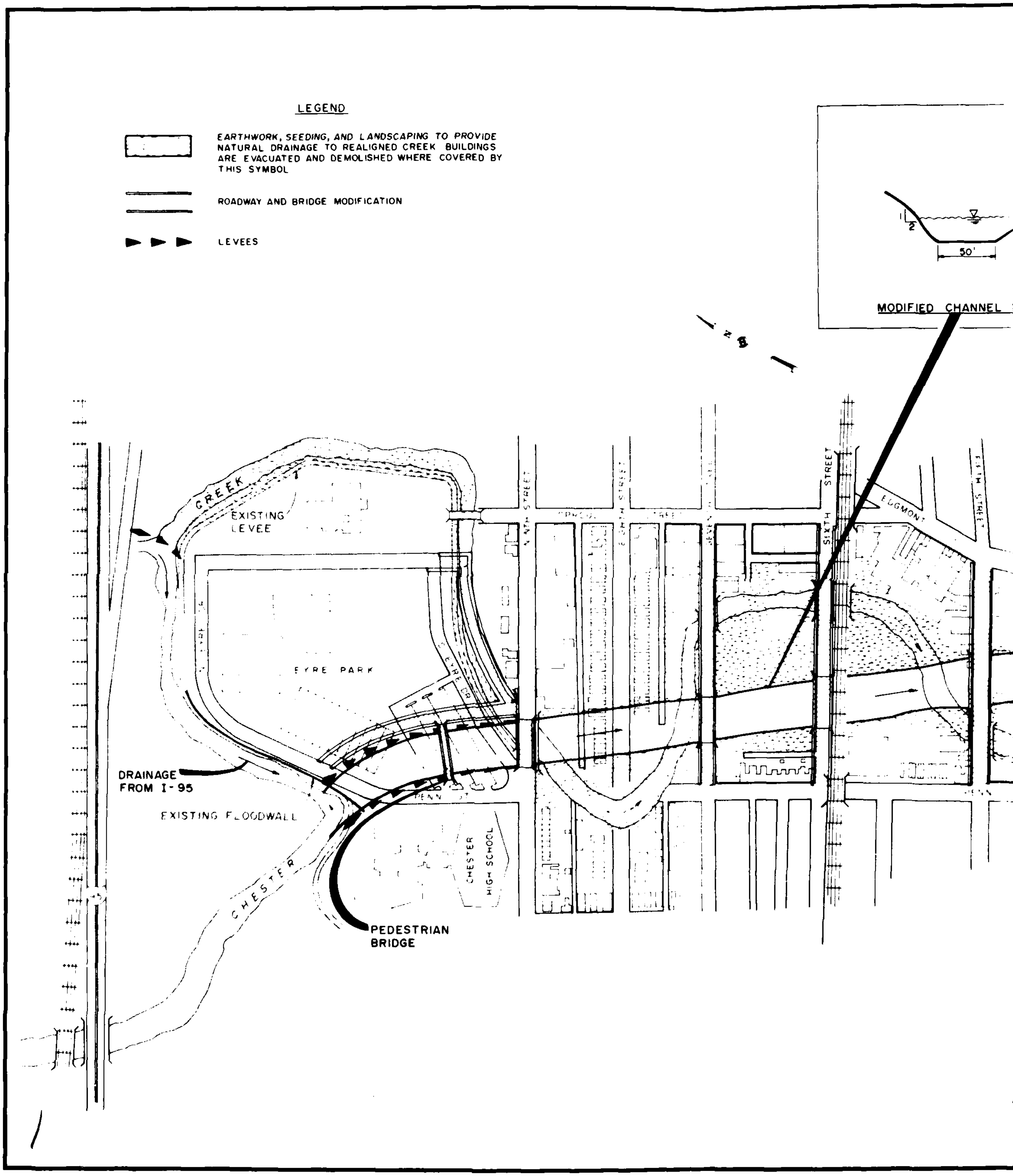
93. The entire municipal parking lot, between Sixth and Seventh Streets, would filled over on the Sproul Street side of the realigned Creek to allow natural drainage. A new lot would then be constructed at a higher elevation with relocated lighting and new accesses off Sixth and Seventh Street. Barrier strips of grassed and landscaped land would be provided on both sides of the Creek to improve the Creek's appearance from the parking lot and homes on Penn Street.

94. As the Creek passes through the Amtrak Viaduct downstream of Sixth Street, transitions of concrete wingwall would be provided between the upstream and downstream channel sections and the fixed section required by the viaduct piers.

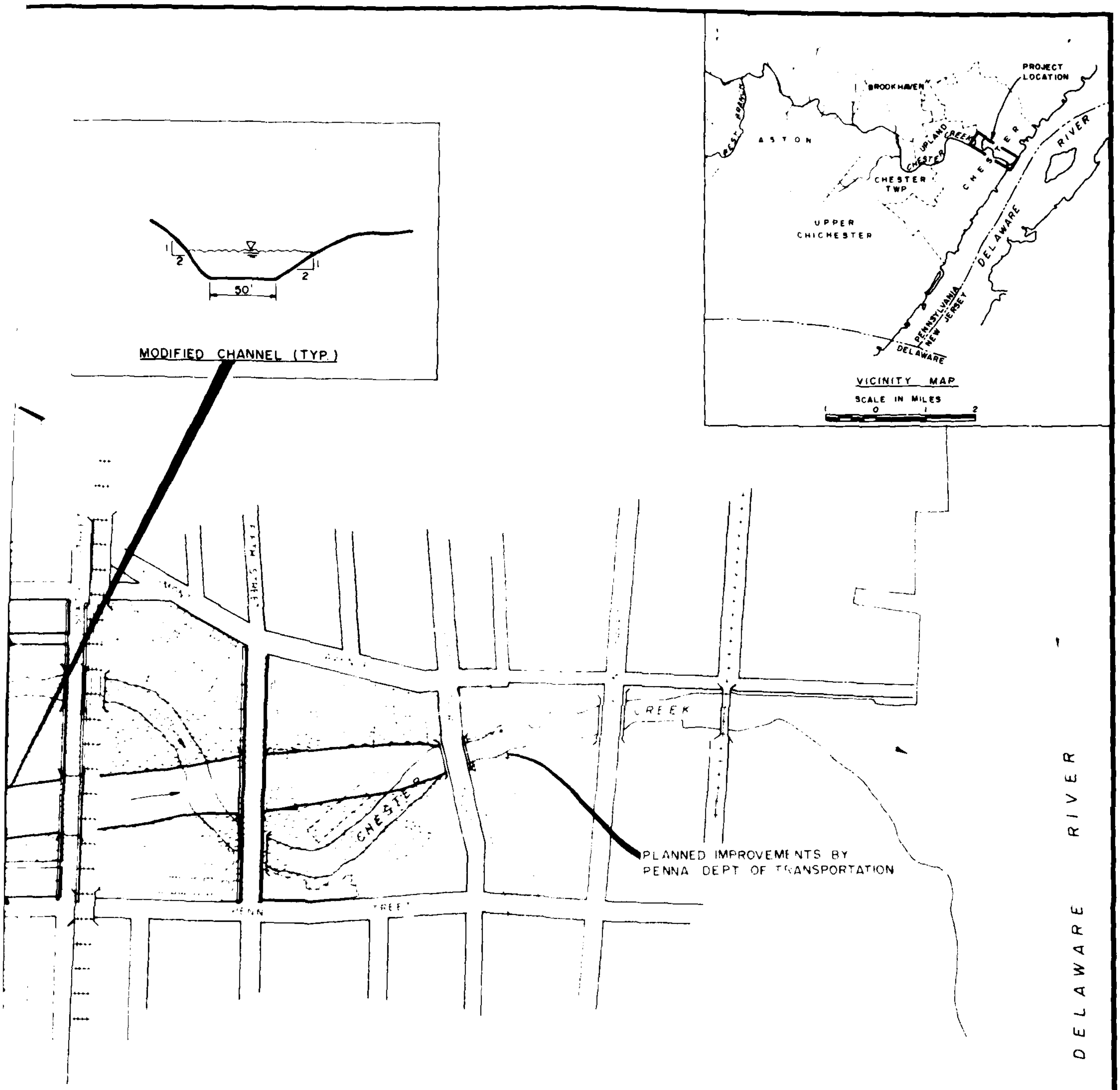
95. The realigned channel would require the acquisition and demolition of 15 homes and 6 commercial or industrial buildings. These residents and businesses would be relocated as part of the project to locations outside the flood plain. In addition, the relocation of the play ground of the Day Care Center at Sixth and Penn Streets would be necessary due to the closeness of the realigned channel.

96. Several changes were made in this plan since it was originally presented to local interests. The realignment was shifted north for about 150 feet and extended to Third Street rather than stopping work at Fifth Street. Extension to Third Street improves the hydraulic performance and lowers downstream flooding which would result if the channel was stopped at Fifth Street.

97. Modifications to the athletic facilities and parking area at the High School are also new project features. These facilities, recently approved, are not compatible with the realignment. The City of Chester changed its traffic circulation pattern since this plan was originally presented, making replacement of the Sixth Street Bridge necessary for traffic flow in the Central Business District. The cost of replacement



LEGEND
EARTHWORK, SEEDING, AND LANDSCAPING TO PROVIDE NATURAL DRAINAGE TO REALIGNED CREEK BUILDINGS ARE EVACUATED AND DEMOLISHED WHERE COVERED BY THIS SYMBOL
ROADWAY AND BRIDGE MODIFICATION
LEVEES
MODIFIED CHANNEL
50'
CREEK
EXISTING LEVEE
EYRE PARK
EYRE DR
DRAINAGE FROM I-95
EXISTING FLOODWALL
CHESTER
PENN ST
CHESTER HIGH SCHOOL
PEDESTRIAN BRIDGE
NINTH STREET
EIGHTH STREET
SIXTH STREET
EDGMONT
FIFTH STREET




CHESTER CREEK BASIN, PENNSYLVANIA

**CHANNEL REALIGNMENT**
**PLAN S3A**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE D-4

was added as part of the project. More extensive work was also required for the parking lot between Seventh and Sixth Streets, to correct drainage problems which would be created by the realigned Creek. This work requires that a new parking lot be provided.

98. Additional subsurface data has indicated an increase in rock excavation. More detailed investigations indicated the need for more utility and drainage relocations and that a channel transition is required for the railroad viaduct. Bridges were also raised to improve the flood water carrying capacity.

99. HYDRAULIC PERFORMANCE. This plan provides some protection to damage reaches 1 through 12 by reducing stages over a range of flows. These areas are represented by Index Stations 1 through 5 on Table D-10. This table shows the stage reductions due to this plan. As is shown, the stage reductions are not very large when compared to the total depth of overbank flooding. At both the lower and higher flood levels, stages are actually increased in downstream reaches. The new channel contains the 10 year storm within its banks so that the increased stages do not result in increased damages. At the SPF level of flooding a one foot increase in stage is relatively insignificant, when compared to the overall flood depth.

100. COSTS. The estimated first cost and annual costs are $7,557,000 and $531,800. A breakdown of first costs by major items is shown below.

PLAN S3A

CONSTRUCTION COSTS

| Item | Cost |
|---|---|
| Channel and Transition (including backfill of existing channel) | $1,888,000 |
| Bridges and Roads | 2,044,000 |
| Eyre Park and Sixth Street Modifications | 388,000 |
| Contingencies @ 25% | 1,080,000 |
| Real Estate & Relocations | 1,171,000 |
| Engineering and Design, Supervision & Administration @ 15% | 986,000 |
| Total First Cost | $7,557,000 |

AVERAGE ANNUAL COST

| | |
|---|---|
| Project Cost Amortized (50-Years, 6-5/8%) | $ 521,800 |
| Annual Operation and Maintenance | 10,000 |
| Total Annual Cost | $ 531,800 |

TABLE D-10
STAGE FEDUCTIONS
PLAN S3A 1/

| Index Station | Location | SPF Exist. | SPF S3A | SPF △ | 100 Year Exist. | 100 Year S3A | 100 Year △ | 50-Year Exist. | 50-Year S3A | 50-Year △ | 10-Year Exist | 10-Year S3A | 10-Year △ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5th Street- Station 22 +10 | 22.4 | 23.5 | -0.9 | 18.1 | 16.6 | +1.5 | 13.9 | 12.5 | +1.4 | 7.5 | 8.0 | -0.8 |
| 2 | 7th Street- Station 33 + 80 | 25.5 | 25.2 | +0.3 | 21.7 | 19.5 | +2.2 | 17.2 | 14.7 | +2.5 | 8.8 | 9.0 | -0.2 |
| 3 | Chester High School- Station 78 + 90 | 32.0 | 27.5 | +4.5 | 25.7 | 20.8 | +4.9 | 21.4 | 16.2 | +5.2 | 13.2 | 10.0 | +3.2 |
| 4 | Kerlin Street- Station 108 + 90 | 33.8 | 30.1 | +3.7 | 26.9 | 23.7 | +3.2 | 23.1 | 20.8 | +2.3 | 16.2 | 15.7 | +0.5 |
| 5 | Toby Farms- Station 176 + 00 | 36.0 | 33.0 | +3.0 | 29.2 | 27.7 | +1.5 | 26.0 | 25.3 | +0.7 | 20.4 | 20.4 | 0 |

1/ Stage reductions are not displayed for Index Station 6 because they were insignificant and damages were reduced by only 1% in damage reach 12.

101. BENEFITS. Existing inundation benefits are estimated to be $162,700 annually. Future annual benefits are $45,500 with total inundation benefits of $208,200 Damage reduction, in percent, by damage reach are presented in Table D-11. In the City of Chester these reductions range up to 59 percent of average annual damages. Bridge replacement benefits of $21,900 annually were computed for the Fifth, Sixth, Seventh and Ninth Street bridges. Unemployment benefits of $27,600 annually were computed with an estimated labor component of 30 percent of the total construction costs.

102. BENEFIT TO COST RATIOS. Benefit to cost ratios are displayed below. The existing benefit to cost ratio is 0.40 to 1.0 and the future ratio is 0.48 to 1.0.

PLAN S3A

| Benefit Conditions | Average Annual Benefits | Average Annual Cost | Benefit to Cost Ratio |
|---|---|---|---|
| Existing Inund. Reduct. | $162,700 | $531,800 | 0.31 |
| Existing Inund. Reduct.<br>Adv. Bridge Repl. | $184,600 | $531,800 | 0.35 |
| Existing Inund. Reduct.<br>Adv. Bridge Repl.<br>Employment | $212,200 | $531,800 | 0.40 |
| Existing Inund. Reduct.<br>Adv. Bridge Repl.<br>Employment<br>Affluence & Urbaniz. | $257,700 | $531,800 | 0.48 |

103. PLAN IMPACTS. The significant impacts of plan S3A are summarized in Table D-12according to one of the following categories: National Economic Development, Environmental Impact, Regional Development, or Social Well-Being.

104. CONCLUSIONS. Plan S3A for channel realignment and bridge replacement in the City of Chester was developed to reduce the effect of Creek bends and constricting bridges. The plan was located so as to minimize real estate acquistion by taking advantage of redevelopment areas. Stage reductions through the City are not large. Real estate costs are high because several businesses and homes in the area must be purchased and Their inhabitants relocated. This area has a low priority for redevelopment. The most favorable benefit to cost ratio is 0.48 to 1.0.

105. Plan S3A does not eliminate the flooding problems and the reduction of the problem is not significant. The impacts of construction on the environment are temporary and permanent, being generally adverse. This plan can not be considered for implementation by the Federal Government.

TABLE D-11
DAMAGE REDUCTION BY REACH
EXISTING AND FUTURE INUNDATION
PLAN S3A 1/

| Index Station | Damage Reach | Damage Reach Locations | Existing Cond. EAAD ($x10000) | Residual EAAD ($x10000) | Percent Reduced 2/ |
|---|---|---|---|---|---|
| 1 | 1 | Delaware Riv. to 2nd St. | $ 7.56 | $ 6.49 | 14% |
| 1 | 2 | 2nd St. to 3rd St. | 18.08 | 15.16 | 16 |
| 1 | 3 | 3rd St. to 5th St. | 31.18 | 8.82 | 72 |
| 1,2 | 4 | 5th St. to 7th St. | 25.93 | 24.87 | 3 |
| 2 | 5 | 7th St. to 9th St. | 65.93 | 40.12 | 39 |
| 3 | 6 | 9th St. to 10th St. | 50.08 | 21.16 | 58 |
| 3 | 7 | 10th St. to I-95 | 11.47 | 4.74 | 59 |
| 4 | 8 | I-95 to Kerlin St. | 79.10 | 49.11 | 38 |
| 4 | 9 | Kerlin St. to Toby Farms | 134.42 | 71.62 | 47 |
| 5 | 10 | Toby Farms Area | 139.95 | 117.30 | 16 |
| 5 | 11 | Toby Farms to Dutton Mill Rd. | 11.61 | 7.92 | 32 |
| 6 | 12 | Dutton Mill Rd. to Knowlton Rd. | 23.50 | 23.25 | 1 |
| 7 to 10 | 13 to 18 | Knowlton Rd to Rt. 1 | - | - | 0 |
| | | Total (Rounded) | $598,800 | $390,600 | 35% |

1/ January 1978 Price Level

2/ $\frac{\text{Existing Cond. EAAD - Residual EAAD}}{\text{Existing Cond. EAAD}}$ = Percent Reduced

TABLE D-12
SIGNIFICANT EFFECT ASSESSMENTS
PLAN S3A

| EFFECTS OF PLAN | ASSESSMENT DURATION 1/ | ASSESSMENT TYPE 2/ |
|---|---|---|
| **National Economic Development** | | |
| Inundation reduction benefits (existing) = 162,500 | P | B |
| Affluence and urbanization benefits = 45,500 | P | B |
| Advance bridge replacement benefits = 21,900 | T | B |
| Increased employment benefits = 27,600 | T | B |
| First Cost = 7,557,000 | P | A |
| O & M Cost = 10,000 | P | A |
| Minor alteration of business patterns during construction | T | A |
| **Regional Development** | | |
| Increased employment during construction and maintenance operations. | T | B |
| Disruption of transportation during construction. | T | A |
| Minor alteration of business patterns during construction. | T | A |
| Increased output of goods and services in Basin. | P | B |
| A 35% reduction in the $598,800 annual damages in the protected areas. | P | B |
| Decreased tax base and employment population caused by changes in flood plan use. | P | A |
| **Environmental Impact** | | |
| Adverse effects on aquatic life during construction. | T | A |
| Loss of natural bank vegetation during construction. | T | A |
| Acoustic, aesthetic, and air quality degradation during project construction. | T | A |
| Historic sites will contine to be flooded. | P | A |
| No known archeological sites are in the project area. | P | - |
| Alteration of natural environment by the disposal of excavated materials for project construction and maintenance. | P | A |
| **Social Well-Being** | | |
| Loss of transporation and utility services during construction. | T | A |
| Reduction of emergency losses and disruption of public services. | P | B |
| No significant effect on recreation potential. | P | - |
| Loss of parking facilities. | P | A |
| Elimination of portions of neighborhoods. | P | A |
| Elimination of flood threat for evacuated businesses and homes. | P | B |

1/ Duration indicates if the effect is permanent (P) or temporary (T).
2/ Type indicates if the effect is beneficial (B), adverse (A), or no change (-).

## PLAN S3Ab

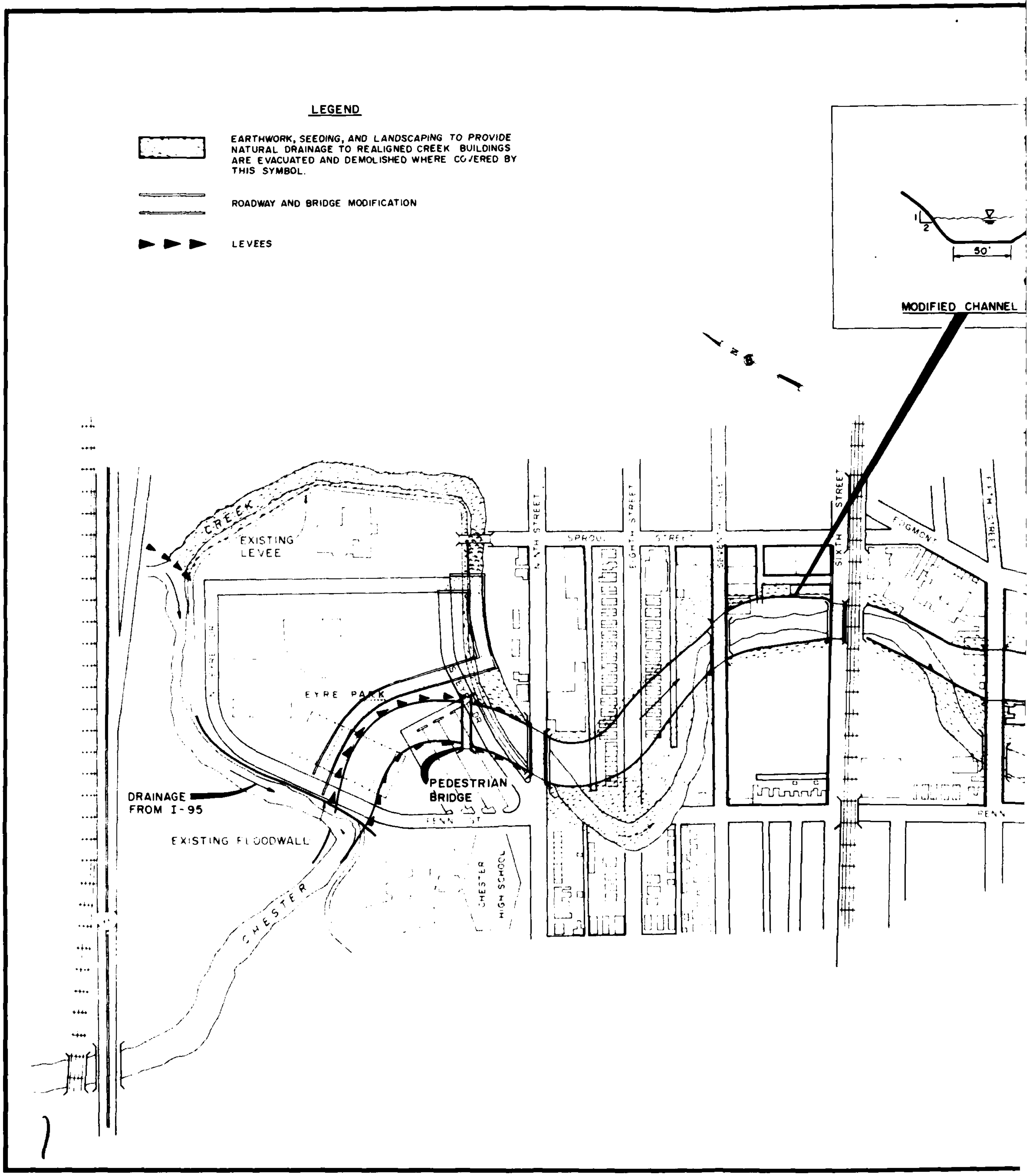
106. This local protection plan is a variation of the S3A channel realignment and bridge modifications. It was investigated to try to improve the economic performance of Plan S3A. Plan S3Ab, by utilizing the existing channel, significantly lowers construction costs for drainage and channel excavation. This plan will sacrifice some hydraulic performance and flood damage reduction (about 4%).

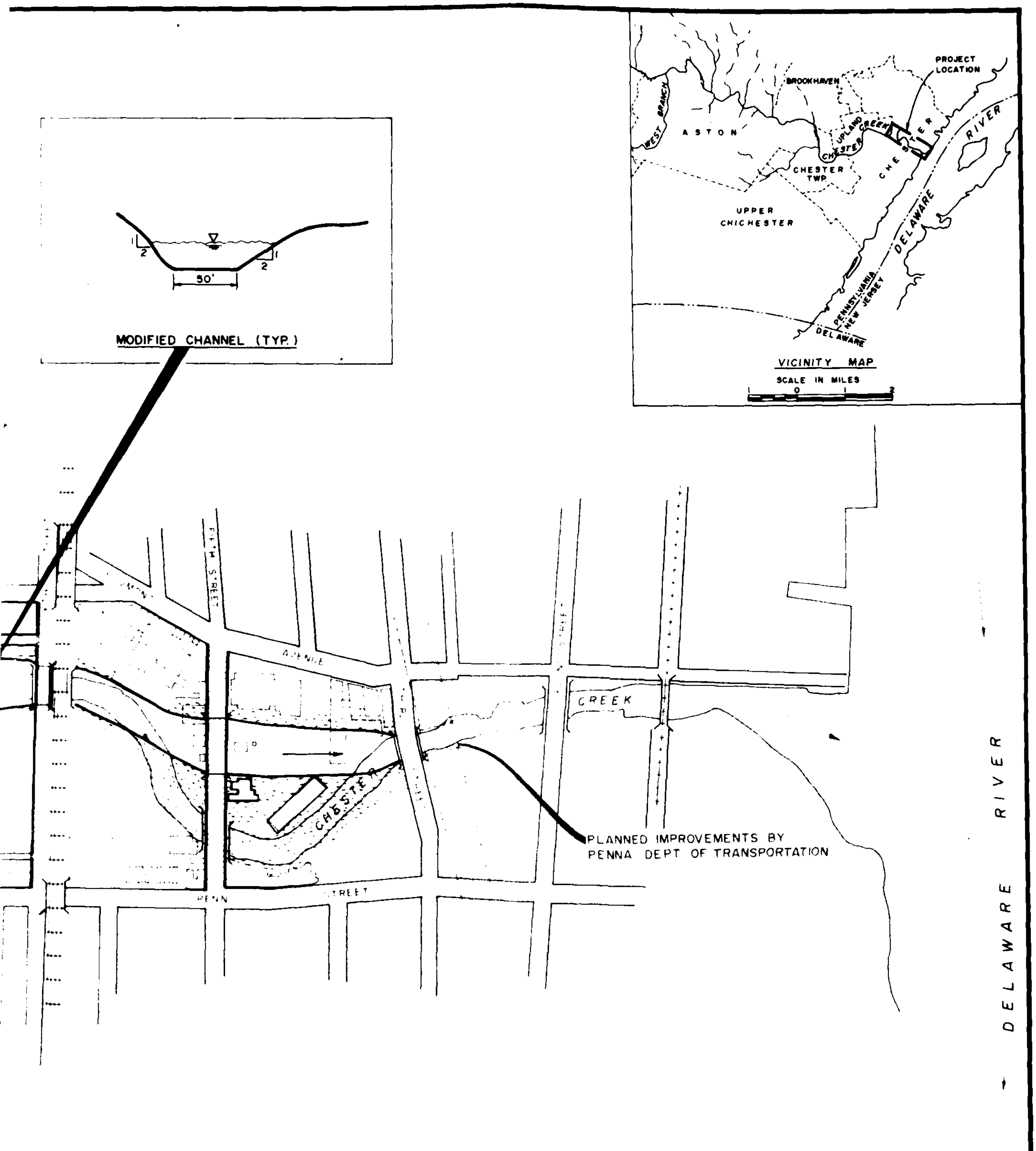
107. The level of protection provided by this plan is not high. It would reduce average annual damages of $599,000 by about 33 percent. In addition to the cost savings, this type of plan was strongly desired by local interests. The plan had potential to be combined with other measures such as flood proofing or flood warning and preparedness, which could further reduce residual damages.

108. TECHNICAL ANALYSIS AND DESIGN. The main features of alternative S3Ab are shown on Plate D-5. This plan involves a new channel through the City of Chester from Eyre Park to Third Street for a distance of about 3,200 feet. The new trapezoidal channel would have a 50 foot bottom width with 2 (horizontal) and 1 (vertical) sideslopes. Channel excavation would be partially through rock where bank protection would not be needed. Non-rock portions of the channel would be seeded above Seventh Street and riprap lined downstream of it. The old channel would be backfilled where the Creek is realigned and the overbank areas would be filled and graded so stormwater can drain naturally to the realigned Creek. The graded surfaces would be seeded and landscaped.

109. New bridges over the Creek would be required at Fifth, Sixth, Seventh, and Ninth Streets. The old bridge at Fifth Street would be replaced by highway section. The bridges at Fifth, Seventh and Ninth Streets would be replaced with spans of about 150 feet and at widths similar to existing. At Sixth STreet a concrete wingwall would be constructed as an upstream transition to the fixed channel width between the piers of the Amtrak Railroad viaduct. Another concrete transition would be required downstream of the viaduct. The new bridges would be elevated so as to pass a 100-year flow without constriction. The bridge at Third Street is planned for replacement through construction of U.S. Highway 13 (PA Route 291). Depending on funding, this construction should be completed some time after 1982. Replacement of the Bridge as part of this flood control plan is therefore unnecessary, since it would be high enough to allow passage of a 100-year flood without constriction.

110. Many modifications would be required at the new High School parking and athletic facilities. The concrete floodwall near the High School would be removed for about 150 feet to allow passage of the


LEGEND
EARTHWORK, SEEDING, AND LANDSCAPING TO PROVIDE NATURAL DRAINAGE TO REALIGNED CREEK BUILDINGS ARE EVACUATED AND DEMOLISHED WHERE COVERED BY THIS SYMBOL.
ROADWAY AND BRIDGE MODIFICATION
LEVEES
MODIFIED CHANNEL
50'
CREEK
EXISTING LEVEE
EYRE PARK
DRAINAGE FROM I-95
EXISTING FLOODWALL
PEDESTRIAN BRIDGE
CHESTER
CHESTER HIGH SCHOOL
NINTH STREET
EIGHTH STREET
SPROUL STREET
SIXTH STREET
EDGMONT
PENN ST




CHESTER CREEK BASIN, PENNSYLVANIA

**CHANNEL REALIGNMENT VARIATION**
**PLAN S3Ab**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

2

PLATE D-5

new channel. Levees would be provided through Eyre Park on both sides of the channel. The existing channel downstream of the I-95 drainage culvert will be filled for a distance of about 2,000 feet and the existing levee removed. The pedestrian bridge at the end of Sproul Street would be demolished and a path provided. The existing levee along North Eyre Drive will be tied into the I-95 embankment and the slope of the existing Creek bed reversed to allow drainage to the realigned Creek. Since the realignment passes through the middle of the High School's new parking facilities, the lot would have to be relocated and access off of Ninth Street provided to the parking lot, athletic fields, and YMCA. A 180 foot long footbridge would be provided to allow access from the High School to the parking lot and fields. Several utilities including sanitary and storm sewers, water lines, and utility poles would have to be relocated in Eyre Park. In addition, further work may show the need for relocation of the new practice football field.

111. At the Sixth Street municipal parking lot, some parking area would be claimed for excavated sideslopes along the existing Creek. Replacement parking would not be provided. A barrier strip of grassed and landscaped land would be provided along the Creek on both sides to improve the Creek's appearance from the parking area and homes on Penn Street.

112. The realigned channel would require the acquisition and demolition of 29 homes and 8 commercial or industrial buildings. These residents and businesses would be relocated as part of the project to locations outside the flood plain.

113. HYDRAULIC PERFORMANCE. This plan provides some protection to damage reaches 1 through 12 by reducing stages over a range of flows. These areas are represented by Index Stations 1 through 5 on Table D-13 This table shows the stage reductions due to this plan. As is shown, the stage reductions are not very large when compared to the total depth of overbank flooding. At both the lower and higher flood levels, stages are actually increased in downstream reaches. The new channel contains the 10 year storm within its banks so that the increased stages do not result in increased damages. At the SPF level of flooding a one foot increase in stage is relatively insignificant, when compared to the overall flood depth.

114. COSTS. The estimated first cost and annual costs are $6,285,000 and $443,900. A breakdown by major item is shown below.

TABLE D-13

STAGE REDUCTIONS - S3Ab 1/

| Index Sta. | Location | SPF Exist. | SPF S3Ab | SPF △ | 100-Year Exit. | 100-Year S3Ab | 100-Year △ | 50-Year Exist. | 50-Year S3Ab | 50-Year △ | 10-Year Exist. | 10-Year S3Ab | 10-Year △ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5th Street - Station 22 + 10 | 22.4 | 23.5 | -0.9 | 18.1 | 16.1 | +1.5 | 13.9 | 12.5 | +1.4 | 7.5 | 8.0 | -0.5 |
| 2 | 7th Street - Station 33 + 80 | 25.5 | 25.2 | +0.3 | 21.7 | 19.5 | +2.2 | 17.2 | 14.7 | +2.5 | 8.8 | 9.0 | -0.2 |
| 3 | Chester High School Station 78 + 90 | 32.2 | 27.5 | +4.5 | 25.7 | 20.8 | +4.9 | 21.4 | 16.2 | +5.2 | 13.2 | 10.0 | +3.2 |
| 4 | Kerlin Street - Station 108 + 90 | 33.8 | 30.1 | +3.7 | 26.9 | 23.7 | +3.2 | 23.1 | 20.8 | +2.3 | 16.2 | 15.7 | +0.5 |
| 5 | Toby Farms - Station 176 + 00 | 36.0 | 33.0 | +3.0 | 29.2 | 27.7 | +1.5 | 26.0 | 25.3 | +0.7 | 20.4 | 20.4 | 0 |

1/ Stage reductions are not displayed for Index Station 6 because they were insignificant and damages were reduced by only 1% in damage reach 12.

PLAN S3Ab

CONSTRUCTION COST

| Item | Cost |
|---|---|
| Channel and Transition (including backfill of existing channel) | $1,219,000 |
| Bridges and Roads | 1,937,000 |
| Eyre Park and Sixth Street Park Modifications | 216,000 |
| Contingencies @ 25% | 843,000 |
| Real Estate and Relocations | 1,250,000 |
| Engineering and Design, Supervision and Administration @ 15% | 820,000 |
| Total First Cost | $6,285,000 |

AVERAGE ANNUAL COST

| | |
|---|---|
| Project Cost Amortized (50-Years, 6-5/8%) | $ 433,900 |
| Annual Operation and Maintenance | 10,000 |
| Total Annual Cost | $ 443,900 |

115. BENEFITS. Existing inundation benefits are estimated to be $156,700 annually. Future annual benefits are $43,800 with total inundation benefits of $200,500. Damage reduction, in percent, by damage reach are presented in Table D-14. In the City of Chester these reductions range up to 59 percent of average annual damages. Bridge replacement benefits of $21,900 annually were computed for the Fifth, Sixth, Seventh and Ninth Street bridges. Unemployment benefits of $26,500 annually were computed with an estimated labor component of 30 percent of the total construction costs.

116. BENEFIT TO COST RATIOS. Benefit to cost ratios are displayed below. The existing benefit to cost ratio is 0.40 to 1.0. With future benefits the ratio is 0.56 to 1.0.

PLAN S3Ab

| Benefit Conditions | Average Annual Benefits | Average Annual Cost | Benefit to Cost Ratio |
|---|---|---|---|
| Existing Inund. Reduct. | $156,700 | $443,900 | 0.35 |
| Existing Inund. Reduct.<br>Adv. Bridge Repl. | $178,600 | $443,900 | 0.40 |
| Existing Inund. Reduct.<br>Adv. Bridge Repl.<br>Employment | $205,100 | $443,900 | 0.46 |
| Existing Inund. Reduct.<br>Adv. Bridge Repl.<br>Employment<br>Affluence & Urbaniz. | $248,900 | $443,900 | 0.56 |

TABLE D-14
DAMAGE REDUCTION BY REACH
EXISTING AND FUTURE INUNDATION
PLAN S3Ab 1/

| INDEX STATION | DAMAGE REACH | DAMAGE REACH LOCATIONS | EXISTING COND. EAAD ($x1000) | RESIDUAL EDDA ($x1000) | PERCENT REDUCED 2/ |
|---|---|---|---|---|---|
| 1 | 1 | Delaware River to 2nd St. | $ 7.56 | $ 6.49 | 14% |
| 1 | 2 | 2nd Street to 3rd Street | 18.08 | 15.16 | 16 |
| 1 | 3 | 3rd Street to 5th Street | 31.18 | 18.14 | 42 |
| 1, 2 | 4 | 5th Street to 7th Street | 25.93 | 23.89 | 8 |
| 2 | 5 | 7th Street to 9th Street | 65.93 | 39.52 | 40 |
| 3 | 6 | 9th Street to 10th Street | 50.08 | 21.16 | 58 |
| 3 | 7 | 10th Street to I-95 | 11.47 | 4.74 | 59 |
| 4 | 8 | I-95 to Kerlin Street | 79.10 | 49.11 | 38 |
| 4 | 9 | Kerlin St. to Toby Farms | 134.42 | 71.62 | 47 |
| 5 | 10 | Toby Farms Area | 139.95 | 117.30 | 16 |
| 5 | 11 | Toby Farms to Dutton Mill Rd. | 11.61 | 7.92 | 32 |
| 6 | 12 | Dutton Mill Rd. to Knowlton Rd. | 23.50 | 23.25 | 1 |
| 7 to 10 | 13 to 18 | Knowlton Rd to Rt. 1 | | | 0 |
| | | TOTAL (Rounded) | $598,800 | $398,300 | 33% |

1/ January 1978 Price Level

2/ $\frac{\text{Existing Cond. EAAD} - \text{Residual EAAD}}{\text{Existing Cond. EAAD}}$ = Percent reduced

117. PLAN IMPACTS. The impacts of plan S3Ab are summarized in Table D-15 according to one of the following categories: National Economic Development, Environmental Impact, Regional Development, or Social Well-Being.

118. CONCLUSIONS. Plan S3A for channel realignment and bridge replacement through the City of Chester was investigated to try to minimize costs for drainage and excavation for channel plans. The alignment contains gradual bends, but these bends are not sensitive and do not increase flood stages (within the accuracy of the model used). This alignment resulted in reduced costs from plan S3A resulting largely from decreased costs for drainage, earthwork, and modification to street bridges and elimination of municipal parking lot. The most favorable benefit to cost ratio for S3Ab is 0.56 to 1.0.

119. Plan S3Ab does not eliminate flooding problems and the reduction of the problem is not significant. The impacts of construction on the environment are permanent and generally adverse. This plan can not be considered for implementation by the Federal Government.

TABLE D-15
SIGNIFICANT EFFECT ASSESSMENTS
PLAN S3Ab

| EFFECTS OF PLAN | ASSESSMENT DURATION 1/ | ASSESSMENT TYPE 2/ |
|---|---|---|
| National Economic Development | | |
| Inundation reduction benefits (existing) = 156,700 | P | B |
| Affluence and urbanization benefits = 43,800 | P | B |
| Advance bridge replacement benefits = 21,900 | T | B |
| Increased employment benefits = 70,800 | T | B |
| First Cost =6,285,000 | P | A |
| O&M Cost = 10,000 | P | A |
| Minor alteration of business patterns during construction | T | A |
| Regional Development | | |
| Increased employment during construction and maintenance operations | T | B |
| Disruption of transportation during construction | T | A |
| Minor alteration of business patterns during construction | T | A |
| Increased output of goods and services in Basin | P | B |
| A 33% reduction in the $598,800 annual damages in the the protected areas | P | B |
| Decreased tax base and employment population caused by changes in flood plain use | P | A |
| Environmental Impact | | |
| Adverse effects on aquatic life during construction | T | A |
| Loss of natural bank vegetation during construction | T | A |
| Acoustic, aesthetic, and air quality degradation during project construction | T | A |
| Historic sites will continue to be flooded | P | A |
| No known archeological sites are in the project area | P | - |
| Alteration of natural environment by the disposal of excavated materials for project construction and maintenance | P | A |
| Social Well-Being | | |
| Loss of transportation and utility services during construction | T | A |
| Reduction of emergency losses and disruption of public services | P | B |
| No significant effect on recreation potential | P | - |
| Loss of parking facilities | P | A |
| Elimination of portions of neighborhoods | P | A |
| Elimination of flood threat for evacuated businesses and homes | P | B |

1/ Duration indicates if the effect is permanent (P) or temporary (T).
2/ Type indicates if the effect is beneficial (B), adverse (A), or no change (-).

## SECTION E

# HYDROLOGIC STUDIES

1. Hydrologic studies were conducted by the Corps' Hydraulic Engineering Center to determine the extent of existing flooding in the Basin, to evaluate the reduction in flood peaks for various flood control measures, and to estimate the effect that future development in the Basin could have on the flood problem and flood control measures. HEC-1 modeling was used.*

2. This section describes the methodology, assumptions, and procedures used in conducting the hydrologic studies and findings. A discussion of the development of past, existing, and future land use patterns for the hydrologic analyses is discussed in Section G, Appendix 1. Due to the relatively small size of the Goose Creek Watershed and its urban drainage type of flooding a separate hydrologic study was made of that portion of the Goose Creek Watershed in the Borough of West Chester and West Goshen Township. Supplemental discussions of items concerning the analysis and results of the Goose Creek hydrology will be presented separately in each sub-section as deemed necessary.

## STUDY AREA

3. There is one streamflow gaging station (USGS gage with drainage area approximately 61.1 square miles) on Chester Creek, with continuous records having been kept since 1932. There are 5 recording precipitation gages and 10 non-recording gages surrounding the Basin which were used in the study (Plate E-1).

## CLIMATE

4. The Chester Creek Basin is within the temperate zone and has a climate that is continental in origin. Winter storms are often caused by

* HEC-1, Flood Hydrograph Package, Generalized Computer Program 723-100, Hydrologic Engineering Center, U.S. Army Corps of Engineers.

low pressure areas that traverse the Atlantic Coast and result in heavy rains. Occasionally, cold fronts from the west and the Great Lakes will bring heavy rains. During the summer, rainfall is usually caused by the westward movement of fronts. However, an occasional tropical storm may result in severe rainfalls through moisture being picked up from the Atlantic Ocean.

5. Precipitation is evenly distributed throughout the year in the Chester Creek Basin. The normal annual precipitation at Chester is about 42.9 inches, with a minimum annual precipitation of 29.3 inches recorded in 1922, and a maximum of 55.3 inches recorded in 1873. Approximately 48% of the annual precipitation normally occurs from May through September. The maximum 24-hour precipitation at Chester was 5.45 inches between 11-12 September 1960. The normal annual snowfall totals about 22 inches. Flooding in the Chester Creek Basin frequently results from localized heavy rainfall. This intense rain falling in a relatively long and narrow drainage area, with its steep side slopes, produces flash flooding throughout the Basin.

## RUNOFF

6. Periods of maximum runoff occur in summer and fall months when thunderstorm activity is high. Some flooding has been caused by snowmelt but this is not as great a problem as that caused by summer storms. The time of concentration of runoff for the entire Basin is on the order of 8-10 hours. Major runoff events are less than 24 hours long. This is due to the short-duration, high-intensity storms; the size of the watershed; and the fairly steep ground slopes throughout the Basin. Average annual runoff is about 18 inches. Two-day runoff during the flood of record was 5-1/2 inches.

## MODEL DEVELOPMENT

7. The general procedures used to develop and analyze Basin hydrology are outlined in Table E-1. More detailed discussions are presented in the following paragraphs. The hydrologic studies consisted of three general tasks; modeling the Basin for existing conditions; projecting future hydrologic conditions due to urbanization, and analyzing different flood control measures. Model development included calibration of five storms. For Goose Creek, supplemental modeling was required in order to develop flow relationships due to storage effects and diversion of flows.

TABLE E-1
HYDROLOGIC MODELING SUMMARY OF
CHESTER CREEK BASIN

MODEL DEVELOPMENT

- The Basin was subdivided into 14 sub-basins.
- Five major storms of record were selected for study.
- Precipitation data from 15 stations and hydrograph records from the USGS gage were analyzed.
- Unit hydrograph and loss-rate coefficients were estimated for the ungaged sub-basins.
- Routing criteria were developed.
- A hydrologic data model was developed using HEC-1.
- The HEC-1 model was calibrated by using storms of record.
- The Standard Project Storm was developed according to U.S. Army Corps of Engineers EM 1110-2-1411 (CEB No. 52-8).
- Standard Project Storm rainfall and adopted loss rates were input into the hydrologic model and discharge hydrographs were computed for each sub-basin and combining points.
- A peak discharge-frequency curve was developed using the log Pearson Type III distribution for the stream gaging station for its period of record, 1932-1972.
- Rainfall distributions having recurrence intervals of 10, 25, and 100 years were developed using U.S. Weather Bureau Technical Paper No. 40.
- Rainfall and adopted loss rates were input into the hydrologic model and discharges were computed for various frequencies in each sub-basin and at the stream gaging station.
- Frequency curves from observed flows and HEC-1 results were compared. The latter was adjusted to the former. This adjustment factor was then used to adjust tributary curves to reflect more realistic frequencies.

URBANIZATION ANALYSIS

- Unit hydrograph parameters and loss rates were modified to account for urbanization, and the effect of this adjustment on downstream flood peaks was evaluated.

ALTERNATIVE ANALYSES

- Storage-outflow functions for reservoir sites were inputted into the HEC-1 model.
- Reservoirs were evaluated under existing and projected future Basin conditions using events generated from rainfall frequency data and frequency curves were adjusted accordingly.
- Flood detention sites were analyzed for potential locations on the main stream and tributaries.

## STUDY AREA MAP

8. The Basin was divided into fourteen (14) sub-basins for study. These are shown on Plate E-2. These sub-basins were selected in consideration of stream junctions, stream gage location, proposed and existing reservoir sites, and locations where distinct changes in topography were noted. However, as the study progresses, further subdividion was required to accommodate the individual reservoir evaluations.

## STORMS OF RECORD

9. Five storms were selected for analysis. These storms had the five largest peak discharges at the USGS gage. The storms selected were 25-26 November 1950; 18-19 August 1955; 11-13 September 1960; 27-28 July 1969; and 12-14 September 1971. Isohyetal maps were developed for the storms and were used to estimate sub-basin average rainfall depths. The maps were developed for each of these storms as shown on Plates E-3 through E-7. Mean rainfall depths were estimated for each sub-basin upstream of the USGS stream gage (Table E-2). The Thiessen polygon method was used as a guide in selecting the appropriate recording rain gages to be used to distribute these totals during each hourly time interval. This method was then used to determine which recording precipitation station(s) were used to distribute total storm rainfall depth for each sub-basin. Flood hydrographs for the five storms of record are also shown on Plates E-3 through E-7.

## UNIT HYDROGRAPH

10. A unit hydrograph study was made on the gaged area (sub-basins 1 through 11) to derive Clark unit hydrograph coefficients, time of concentration (TC), and storage coefficient (R). The values obtained were compared to the regionalized relationship:*

$$(TC + R) = 10a \left( \frac{DA}{S_{st}} \right)^{0.25}$$

where "a" is a coefficient

* "North Atlantic Region Water Resources Study, App. C, Climate Meteorology and Hydrology," February 1972, North Atlantic Division Corps of Engineers.

TABLE E-2
SUB-BASIN RAINFALL DEPTHS, RECORDERS AND LOSSES
USED IN HEC-1
FOR FIVE (5) STORM ANALYZED

| Sub-basin No.[1/] | Drainage Area (sq. mi.) | 12-14 September 1971 | | 27-29 July 1969 | | 11-13 September 1960 | | 18-19 August 1955 | | 25-26 November 1950 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sub-basin Precipitation (in.) | Rainfall Recorder[2/] | Sub-basin Precipitation (in.) | Rainfall Recorder[2/] | Sub-basin Precipitation (in.) | Rainfall Recorder[2/] | Sub-basin Precipitation (in.) | Rainfall Recorder[2/] | Sub-basin Precipitation (in.) | Rainfall Recorder[2/] |
| 1 | 8.40 | 11.90 | 220 | 5.43 | 100 | 7.70 | 220 | 4.30 | 220 | 6.20 | 220 |
| 2 | 3.32 | 11.90 | 220 | 5.25 | 100 | 7.60 | 220 | 5.00 | 220 | 6.00 | 220 |
| 3 | 8.04 | 12.30 | 220 | 5.35 | 100 | 7.50 | 220 | 4.50 | 180 | 5.70 | 220 |
| 4 | 6.44 | 12.00 | 220 | 5.15 | 100 | 7.50 | 220 | 5.20 | 220 | 5.80 | 220 |
| 5 | 9.74 | 11.70 | 220 | 4.95 | 100 | 7.55 | 220 | 4.40 | 100 | 5.60 | 220 |
| 6 | 4.92 | 12.20 | 220 | 5.13 | 100 | 7.10 | 130 | 4.70 | 180 | 5.30 | 220 |
| 7 | 4.91 | 11.70 | 220 | 5.00 | 100 | 6.80 | 130 | 3.40 | 140 | 4.90 | 220 |
| 8 | 3.35 | 12.10 | 220 | 5.00 | 100 | 7.30 | 130 | 3.90 | 140 | 5.30 | 220 |
| 9 | 4.16 | 12.00 | 220 | 4.92 | 100 | 7.20 | 130 | 3.00 | 140 | 5.00 | 220 |
| 10 | 1.76 | 11.60 | 220 | 4.86 | 100 | 7.50 | 130 | 2.90 | 100 | 5.30 | 220 |
| 11 | 6.06 | 11.30 | 220 | 4.74 | 100 | 7.55 | 220 | 2.90 | 100 | 5.30 | 220 |
| Average Precipitation | | 11.90" | | 5.10" | | 7.43" | | 4.23" | | 5.56" | |
| Initial Loss | | 3.00" | | 2.60" | | 2.30" | | 1.30" | | .70" | |
| Constant Loss | | .15"/Hr. | | .08"/Hr. | | .20"/Hr. | | .10"/Hr. | | .20"/Hr. | |

Rainfall Recorders:

| | |
|---|---|
| 100 | Philadelphia Weather Service Office (WB Airport) |
| 130 | Wilmington N. Castle Weather Service Office (WB Airport) |
| 140 | Newark University Farm |
| 180 | Coatesville 1 SW |
| 220 | Phoenixville 1E |

1/ Only the sub-basins upstream of the USGS gage were included in the model of the historical events. Sub-basins 12, 13 and 14 have drainage areas of 3.36, 1.58 and 1.86 respectively and were included in hypothetical event analyses.

2/ The recorders 100 and 220 were used for all sub-basins in the cases of 1971 and 1950 events because they resulted in hourly distribution of rainfall which best reconstituted the observed hydrographs.

DA = drainage area in square miles

$$S_{st} = \left( \frac{n}{\sum \frac{1}{\sqrt{S_i}}} \right)^2 \qquad i = 1,2,3\ldots n$$

where

$S_{st}$ = main channel slope in feet per foot

$n$ = number of equal increments of the longest watercourse

$S_i$ = slope of individual channel increment in feet per foot

11. An optimization feature of HEC-1 was used to compute the unit hydrograph parameters. Program input for each storm consisted of (1) mean storm rainfall for the Basin, (2) hourly precipitation data from recording stations that provide a distribution pattern for the mean rainfall, (3) Basin drainage area, and (4) the observed runoff hydrograph. Rainfall and loss parameters were tabulated for each storm. Data presented in Plates E-3 through E-7 were weighted averages for the total area contributing to runoff at the USGS gage sub-basins 1 through 11.

12. Several refinement runs were made until the computer-generated hydrographs approximated the observed hydrographs in shape, timing, and volume. Initial and constant loss rate values were used for these runs. The final derived unit hydrograph and unit hydrograph parameters are shown on Plate E-8. The average of the final (TC + R) values is 11.8. This average does not include the 1971 flood because (1) the shape of the observed hydrograph is not typical of the type of hydrograph that normally occurs (Plates E-3 through E-7), in that the time to peak is not representative; (2) the unit hydrograph values obtained are considered extreme (Plate E-8); and (3) a typical unit hydrograph was desired to calculate flood hydrographs whose shape, timing, and volume could be expected to occur most of the time for the type of storm patterns that occur over the Basin. Substituting Basin and average unit hydrograph characteristics for Chester Creek at the USGS gage (D.A. = 61.1, $S_{st}$ = 24.8, (TC + R) = 11.8) into the regional equation and solving for "a", a computed coefficient of 0.94 is obtained. This compares well with data contained in the North Atlantic Regional Report where nearby basins to the north and south of Chester Creek have values of 1.06 and .70. The 24.8 feet per mile slope for Chester Creek was taken from Appendix M of the Report on the Comprehensive Survey of the Water Resources of the Delaware River Basin, Philadelphia District, Corps of Engineers, 1960.

13. The general form of the regional equation was adopted for computing the (TC + R) values for each of the sub-basins of Chester Creek used in

the model. Because of the effort required to compute the $S_{st}$ slope, an average slope computed for each sub-basin was substituted for $S_{st}$ and "a" was adjusted to 1.05 to compensate for the larger values of average slope. A ratio of R/(TC + R) of 0.2 was adopted as a reasonable value for the smaller sub-basins of the Chester Creek, as compared to the four storm average of 0.3 for the 61.1 square mile basin at the USGS gage. The final adopted TC and R values for the sub-basins are tabulated in Table E-3.

## ROUTING CRITERIA

14. The Muskingum linear routing technique was used in the Basin HEC-1 model. The Muskingum K's were estimated using the following equation:

$$K = \frac{L}{V}$$

where:

| | | |
|---|---|---|
| K | = | estimated Muskingum K in hours |
| L | = | routing reach length in miles |
| V | = | estimated average reach travel time in m.p.h. |

15. A Basin average flow velocity of two mph was estimated using Manning's equation. A slope was determined for each routing reach. An average of the channel slopes of the main channel, the East and West Branches was about 18 feet per mile. A value of 0.04 for Manning's "n" was based on field inspections of the channel. The Muskingum K values that were estimated using this approach proved adequate in reproducing the observed hydrographs reasonably well. The final adopted K and X values are tabulated in Table E-4. The parameter (NSTPS) designates the number of sub-reaches within each routing reach used to bring K and the routing time interval ($\Delta t$) within an acceptable range. Theoretically, $\Delta t$ and K should be nearly equal, in which case NSTPS = $K/\Delta t$, but reasonable departure from this is not critical. "X" is a weighting factor for channel reach inflow to account for the water surface not being parallel to the channel slope during unsteady flow. It can range from zero for reservoir-type storage effect to 0.5 for pure translation.

16. After the HEC-2 water surface profile runs were completed, storage-discharge data were plotted for routing reaches between the confluence of Chester Creek with its West Branch and the mouth at the Delaware River. The curves were reviewed for linearity and the K's were calculated for the linear portions of the curve using the following equation for a time interval of one hour:

TABLE E-3
SUB-BASIN UNIT HYDROGRAPH AND
RUNOFF HYDROGRAPH PARAMETERS
CHESTER CREEK BASIN

| Sub-basin No. | D.A. (sq. mi.) | TC (hrs.) | R (hrs.) | STRTQ (cfs) | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 1971 | 1969 | 1960 | 1955 | 1950 |
| 1 | 8.40 | 5.88 | 1.49 | 80 | 16 | 40 | 24 | 8 |
| 2 | 3.32 | 4.80 | 1.22 | 30 | 6 | 15 | 9 | 3 |
| 3 | 8.04 | 6.00 | 1.52 | 80 | 16 | 40 | 24 | 8 |
| 4 | 6.44 | 5.40 | 1.37 | 60 | 12 | 30 | 18 | 6 |
| 5 | 9.74 | 5.52 | 1.40 | 100 | 20 | 50 | 30 | 10 |
| 6 | 4.92 | 5.16 | 1.31 | 50 | 10 | 25 | 15 | 5 |
| 7 | 4.91 | 5.52 | 1.40 | 50 | 10 | 25 | 15 | 5 |
| 8 | 3.35 | 4.20 | 1.07 | 40 | 8 | 20 | 12 | 4 |
| 9 | 4.16 | 4.44 | 1.13 | 50 | 10 | 25 | 15 | 5 |
| 10 | 1.76 | 3.24 | .82 | 20 | 4 | 10 | 6 | 2 |
| 11 | 6.06 | 4.68 | 1.19 | 60 | 12 | 30 | 18 | 6 |

QRCSN = .06 x Peak Discharge

RTIOR = 2.0

Definition of Variables:

| | |
|---|---|
| TC | Time of concentration in hours for Clark unit graph |
| R | Storage coefficient in hours for Clark unit graph |
| STRTQ | Flow in cfs at start of storm |
| QRCSN | Flow in cfs below which base flow recession occurs in accordance with the logarithmic recession constant RTIOR |
| RTIOR | Ratio of recession flow, QRCSN, to that flow occurring 10 tabulation intervals later |

## TABLE E-4
## ROUTING DATA
## CHESTER CREEK BASIN

Muskingum Routing

| Reach No. | Reach Length (miles) | NSTPS | K (hrs) | X |
|---|---|---|---|---|
| 0102 1/ | 2.35 | 1 | 1.8 | .3 |
| 0304 | 3.58 | 1 | 2.4 | .3 |
| 0405 | 4.52 | 1 | 1.9 | .4 |
| 0708 | 3.33 | 1 | 1.4 | .4 |
| 0910 | 2.42 | 1 | .8 | .4 |
| 1011 | 3.58 | 1 | 1.8 | .4 |

1/ Reach No. nomenclature "0102" designates the reach between the downstream points of sub-basin 1 and sub-basin 2.

Modified Puls Routing

| Reach No: | 1112 | | 1213 | | 1314 | |
|---|---|---|---|---|---|---|
| Length (miles): | 1.60 | | 1.99 | | 1.73 | |
| | Storage (ac. ft.) | Discharge (cfs) | Storage (ac. ft.) | Discharge (cfs) | Storage (ac. ft.) | Discharge (cfs) |
| NSTPS = 1 | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 |
| | 200 | 3,000 | 300 | 3,000 | 210 | 3,000 |
| | 250 | 6,000 | 550 | 6,000 | 370 | 6,000 |
| | 330 | 10,000 | 900 | 10,000 | 610 | 10,000 |
| | 790 | 21,000 | 2,100 | 21,000 | 1,100 | 21,000 |
| | 980 | 28,000 | 2,710 | 28,000 | 1,380 | 28,000 |
| | 1,190 | 36,000 | 3,420 | 36,000 | 1,700 | 36,000 |

Definition of Variables:

NSTPS: Number of routing steps

K: Muskingum K coefficient in hours (reach travel time)

X: Muskingum X coefficient

$$K = \frac{(S_2 - S_1)\ (12.1)}{Q_2 - Q_1}$$

where:

K = Muskingum K in hours

S = storage in acre-feet

Q = flow in c.f.s.

The estimated K for the routing reach between the USGS gage and the confluence of Chester Creek with its West Branch was based on Manning's equation (paragraph 15). This was then checked against the K derived using the storage-discharge curve developed from HEC-2 for this routing reach (Plate E-9). The estimated K of 1.8 compared favorably to the derived K of 1.4 (for discharges less than 12,000 cfs). Storage-discharge data and modified puls routing technique were used for routing reaches downstream of the gage. Plate E-9 shows the plotting of the storage-discharge data used for each routing reach.

## FREQUENCY STORM

17. Storms of various frequencies were developed for the Chester Creek Basin. The storms chosen were the Standard Project Storm (SPF) and those with recurrence intervals of 100, 25 and 10-years. The SPF rainfall depth and distribution for the Chester Creek study area was developed using Civil Engineer Bulletin No. 52-8. The precipitation index for the Basin is 10.5 inches, corresponding to a drainage area of 68 square miles. Using a transposition factor of 1.0, the SPF rainfall distribution was developed (Table E-5) for a tabulation time interval of one hour. An adjustment was not made to the unit hydrograph shape to account for timing differences during extremely rare events (such as SPF and PMF)*. The 100, 25, and 10-year storms were developed using U.S. Weather Bureau Technical Paper No. 40. The rainfall distributions that were used for each of the storms are shown on Table E-5 for a typical 20-square mile sub-basin. The rainfall depth-area data developed for the HEC-1 Basin model are shown on Table E-6. The computed peak discharges at various locations within the Basin for the SPF, 100, 25, and 10-year storms are shown on Table E-7.

* The Standard Project Flood (SPF) is the flood resulting from the occurrence of the most severe combination of hydrometeorological conditions reasonably characteristic of the geographic region of concern, excluding extremely rare combinations. The probable maximum flood (PMF) is a flood resulting from the most severe combination of hydrometeorological conditions that are considered reasonably possible for the region of concern. Generally the SPF is in the order of 40 to 60 percent of the PMF.

TABLE E-5
RAINFALL DISTRIBUTION FOR HYPOTHETICAL STORMS
CHESTER CREEK BASIN
(Typical 20 Square Mile Sub-Basin)

| Hours | SPF | 100 year | 25 year | 10 year |
|---|---|---|---|---|
| | ------Rainfall in Inches------ | | | |
| 1 | .07 | .03 | .01 | .02 |
| 2 | .07 | .04 | .01 | .02 |
| 3 | .07 | .05 | .02 | .03 |
| 4 | .08 | .06 | .03 | .04 |
| 5 | .08 | .07 | .04 | .05 |
| 6 | .08 | .08 | .05 | .06 |
| 7 | .11 | .08 | .06 | .07 |
| 8 | .14 | .09 | .07 | .08 |
| 9 | .18 | .16 | .15 | .10 |
| 10 | .23 | .17 | .16 | .11 |
| 11 | .31 | .17 | .16 | .11 |
| 12 | .44 | .18 | .16 | .12 |
| 13 | .94 | .22 | .16 | .15 |
| 14 | 1.13 | .27 | .22 | .20 |
| 15 | 1.41 | .78 | .61 | .53 |
| 16 | 3.56 | 3.11 | 2.46 | 2.14 |
| 17 | 1.31 | .34 | .33 | .29 |
| 18 | 1.03 | .24 | .17 | .16 |
| 19 | .29 | .20 | .16 | .14 |
| 20 | .19 | .19 | .16 | .13 |
| 21 | .15 | .14 | .13 | .10 |
| 22 | .11 | .12 | .11 | .09 |
| 23 | .07 | .11 | .09 | .09 |
| 24 | .05 | .10 | .07 | .08 |
| Total | 12.10 | 7.00 | 5.59 | 4.91 |

TABLE E-6
RAINFALL DEPTH DATA FOR HYPOTHETICAL STORMS
CHESTER CREEK BASIN

| D. A. (sq. mi.) | SPF | 100-year | 25-year | 10-year |
|---|---|---|---|---|
| | ------ 24 Hour Rainfall in Inches ------ | | | |
| 1 | 12.92 | 7.20 | 5.75 | 5.05 |
| 10 | 12.38 | 7.08 | 5.66 | 4.97 |
| 20 | 12.10 | 7.00 | 5.59 | 4.91 |
| 40 | 11.76 | 6.88 | 5.50 | 4.83 |
| 70 | 11.34 | 6.80 | 5.43 | 4.77 |

D. A. = Drainage Area

TABLE E-7
COMPUTED PEAK DISCHARGES AT VARIOUS STREAM LOCATION
FOR HYPOTHETICAL FLOODS
CHESTER CREEK BASIN
(EXISTING CONDITIONS)

| Description of Stream Location | Drainage Area (sq. mi.) | SPF | 100-Year | 25-Year | 10-Year |
|---|---|---|---|---|---|
| Chester Creek @ Confluence with East Branch (Sub-basins 1, 2 and 3 combined) | 19.76 | 16,900 | 9,680 | 5,860 | 4,090 |
| Chester Creek @ Hillis Road (Sub-basins 1 through 4) | 26.20 | 18,500 | 10,400 | 6,160 | 4,270 |
| Chester Creek before Confluence with West Branch (Sub-basins 1 through 5) | 35.94 | 21,600 | 11,900 | 7,010 | 4,760 |
| West Branch @ Markham (Sub-basins 6 and 7 combined) | 9.83 | 9,920 | 5,830 | 3,570 | 2,540 |
| Green Creek before Confluence with West Branch (Sub-basin 9) | 4.16 | 4,710 | 2,820 | 1,820 | 1,290 |
| West Branch @ Confluence with Green Creek (Sub-basins 6, 7, 8 and 9) | 17.34 | 15,900 | 9,260 | 5,600 | 3,980 |
| West Branch before Confluence with Cester Creek (Sub-basins 6 through 10) | 19.10 | 16,800 | 9,670 | 5,870 | 4,120 |
| Chester Creek @ Confluence with West Branch (Sub-basins 1 through 10) | 55.04 | 35,400 | 20,200 | 12,000 | 8,170 |
| Chester Creek @ USGS Gage (Sub-basins 1 through 11) | 61.1 | 35,800 | 20,300 1/ | 11,900 1/ | 8,090 1/ |
| Chester Creek @ Confluence with Baldwin Run (Sub-basins 1 through 12) | 64.5 | 32,400 | 18,500 | 10,700 | 7,240 |
| Chester Creek @ Highway 95 (Sub-basins 1 through 13) | 66.0 | 29,600 | 16,900 | 9,720 | 6,540 |
| Mouth of Chester Creek (Sub-basins 1 through 14) | 67.9 | 27,500 | 15,700 | 9,000 | 6,030 |

1/ Values for 100-, 25-, and 10-year periods were computed from the model and respective hypothetical storms. Final adopted values at the USGS gage location were derived from the discharge-frequency analysis and are shown on Table E-8.

## FREQUENCY ANALYSIS

18. A discharge-frequency analysis was made for the period of record (1932-1972) for the USGS streamflow gage. The HEC computer program No. 723-X6-L2350, "Regional Frequency Computation," was used to process input data; annual peak, one-day, three-day, and seven-day flows. The program used log-Pearson Type III distribution.

19. Plate E-10 shows the computed annual peak discharge versus frequency relationship, which has an adjusted long-term mean discharge of 3,200 cfs (mean log equal 3.507), a standard diviation of 0.295, and an adopted skew of 0.4. The computed skew coefficient of the logs was .758; however, because the skew coefficient can be an unreliable statistic, the regional value of 0.4 was adopted. The 5 and 95 percent confidence limits are also shown. Expected probability theory was used. However with a 65-year equivalent period of record, there is only a minor difference (about 7 percent higher at the 1 percent exceedence frequency). No adjustment was made for a partial duration series since damages are minor for events less than the 10 percent chance event and discharge adjustments for the less frequent events are negligible.

20. Plate E-11 shows 1-day, 3-day and 7-day runoff-frequency curves computed in the same manner as the annual peak series but without adjustment to a long-term base, since the relative minor adjustment displayed by the peak series indicated the 1932-1972 period was representative of a longer-term period. These statistical curves were used to check the computed peak discharge and runoff volume at the gage for each of the frequency storms that were run using the HEC-1 Basin model and the stream system computation feature of HEC-1. An initial loss of 2.0 inches and a constant loss rate of 0.1 inch/hour were used in the model for each of the selected storm frequencies. Plotting results against the frequency curve indicated that the HEC-1 results departed somewhat from the recorded event analysis; therefore, 10-year and 100-year losses were adjusted so that HEC-1 computed discharges approximated curve values of recorded events.

21. Table E-8 shows a comparison between the discharges from the curve (Plate E-10) and HEC-1 computed discharges at the USGS gage. A comparison of volumes from Plate E-11 and the HEC-1 computed volumes at the gage is also shown. From the comparison it was concluded that the HEC-1 Basin model was computing reasonable peak discharges and peak volumes at the gage. It was, therefore, concluded that the peak discharges and computed volumes along the main stem and West Branch Chester Creek are also reasonable. HEC-1 computed discharges were used for defining the flooding problems, computing flood damages and benefits, and predicting effects of future urbanization. Discharges not computed by HEC-1 were

TABLE E-8
COMPARISON OF PEAK AND VOLUME RESULTS AT USGS
GAGE USING HEC-I AND COMPUTED FREQUENCY CURVES
FOR HYPOTHETICAL FLOODS

| Hypothetical Flood | Peak Discharge HEC-I | Peak Discharge Curve 3/ | 1-Day Volume 1/ HEC-I | 1-Day Volume 1/ Curve 4/ | 3-Day Volume 2/ HEC-I | 3-Day Volume 2/ Curve 4/ | HEC-I Losses Initial (in.) | HEC-I Losses Constant (in./hr.) |
|---|---|---|---|---|---|---|---|---|
| | -----(cfs)---- | | ----------(mean flow - cfs)------- | | | | | |
| SPF 5/ | 35,800 | -- | 14,600 | 11,000 5/ | 6,300 | 4,500 5/ | 2.0 | .10 |
| 100-Year | 20,300 | 21,000 | 8,380 | 6,260 | 3,680 | 2,700 | 1.5 | .05 |
| 50-Year | -- | 16,000 | -- | 5,000 | -- | 2,200 | -- | -- |
| 25-Year | 11,900 | 12,000 | 4,710 | 3,800 | 2,120 | 1,710 | 2.0 | .10 |
| 10-Year | 8,090 | 8,100 | 3,130 | 2,640 | 1,440 | 1,220 | 2.0 | .18 |

1/ HEC-I values represent a maximum 24-hour volume.
Curve values represent a maximum day volume (000 - 2400 hrs).

2/ HEC-I values represent a maximum 72-hour volume.
Curve values represent a maximum 3-day volume (0000-2400 hrs. each day).

3/ Information taken from Plate E-10.

4/ Information taken from Plate E-11.

5/ Comparative values were taken at the 0.2 percent exceedence frequency.

taken from the curve on Plate E-10. The discharge-frequency information from the curve (Plate E-10) was used in all HEC-2 computations. Use of computed or curve values was a matter of preference since there were no significant differences in discharge values, and modeling results are not sensitive to such slight variations in discharges used.

## GOOSE CREEK MODEL

22. The supplemental model for the Goose Creek Watershed was done basically the same as the Basin model. The primary difference was the additional sub-division of the Goose Creek Watershed and a finer definition of flow characteristics in order to simulate the urban drainage nature of flooding. A summary outline of the development of this supplemental model is presented below.

Hypothetical storm return period of 10-year, 25-year and 100-year were analyzed

Rainfall distributions were computed:
- Hourly - preliminary analysis
- 15 minute - final analysis. Generated from hourly rainfall distribution mass curve

Watershed was divided into 18 sub-basins (Plate E-12)

Physical characteristics of surface areas which were tabulated were length, drainage area, and channel slope

TC and R were calculated for each sub-basin based on their physical characteristics

Muskingum coefficients, K and X, were calculated and adopted for each section of channel

Initial loss rate (STRTL) was set at 1.55 inches and constant loss rate (CNSTL) was set at 0.14 inches/hour

STRTQ and QRCSN for each sub-basin were calculated as 10% of $Q_p$ (which was calculated by the rational formula)

Routing storage-outflow curves were developed at the confluence of Goose Creek and East Branch Goose Creek (nodal point 200, Plate E-12).

## EFFECTS OF URBANIZATION

23. Future urban development in the Chester Creek Basin will cause

changes in the streamflow regimen. Magnitudes of peak flows will be increased and the times to peak flows will be reduced due to diminished infiltration and improved conveyance. Urbanization will have a greater effect on the more frequent floods.

## INDEX OF URBANIZATION

24. Urbanization was measured by computing the percentage of impervious surfaces within each of the 14 sub-basins. Land use categories and percent impervious values used in this study are shown on Table E-9. The percent imperviousness values were selected following research of the "state of the art" values. Values were selected from "Magnitude and Frequency of Floods in New Jersey with Effects of Urbanization," Special Report 38, State of New Jersey, Department of Environmental Protection, Division of Water Resources, 1974. This study's values are presented in Table E-10.

25. Each category was assigned an index value representing the percent of imperviousness. A weighted-area method was then utilized to determine the percent of impervious surface within each sub-basin of the Chester Creek Basin, according to the following relationship:

$$I = \frac{\sum_{j=1}^{n} a_j i_j}{A}$$

where:

| | | |
|---|---|---|
| I | = | percent impervious surfaces within a sub-basin |
| A | = | drainage area of sub-basin (acres) |
| a | = | defined area for a specified land-use classification within a sub-basin (acres) |
| i | = | index value (see Table B-9) representing the percent of imperviousness corresponding to a specified land-use classification |
| n | = | total number of land-use categories within a sub-basin |

26. Land use patterns for the years 1940, 1970, 1980, 1990, 2000, 2010 and 2020 were determined for both limited and full growth estimates. Limited and full growth are described in Appendix 1, Section G. Changes in impervious areas vs. time for portions of the Chester Creek Basin are presented on Plate F-13.

## UNIT HYDROGRAPH CHARACTERISTICS

27. Unit hydrographs were modified to reflect urbanization. Particular

## TABLE E-9
## INDEX VALUES OF IMPERVIOUSNESS FOR LAND-USE DESIGNATIONS WITHIN CHESTER CREEK BASIN CHESTER CREEK BASIN

| Land-use category | Impervious land area (percent) | | |
|---|---|---|---|
| | Low | Intermediate | High |
| Single-family residential | 12 | 25 | 40 |
| Multiple-family residential | 60 | 70 | 80 |
| Commercial | 80 | 90 | 100 |
| Industrial | 40 | 70 | 90 |
| Public and quasi-public | 50 | 60 | 75 |
| Conservational, recreational and open | 0 | 0 | 1 |

1/ "Magnitude and Frequency of Floods in New Jersey with Effects of Urbanization," Special Report 38, State of New Jersey, Department of Environmental Protection, Division of Water Resources, 1974.

## TABLE E-10
## IMPERVIOUS LAND AREA WITHIN LAND-USE CATEGORIES CHESTER CREEK BASIN 1/

| Land-use category 1/ (units per acre) | | Index value, i (percent imperviousness) |
|---|---|---|
| Residential | | |
| I | .67 - .99 | 12 |
| II | 1.0 - 4.9 | 29 |
| III | 5.0 - 8.9 | 46 |
| IV | 9.0 - 16.9 | 63 |
| V | Greater than 16.9 | 80 |
| Commercial | | 90 |
| Industrial | | 70 |
| Right-of-way (roads and streets) | | 100 |
| Open | | 0 |

1/ Reference is made to Urbanization Analysis, Appendix I, Section G.

unit hydrograph parameters were mathematically related to physiographic and meteorological characteristics for existing and future conditions. A multiple regression model developed by the Hydrologic Engineering Center of the Corps of Engineers (Generalized Computer Program 704-GI-L2020) was used in this analysis. The model requires a base-10 logarithmic transformation of both dependent and independent variables such that the resulting equations are of the form:

$$\log \{Y\} = \log b + \sum_{j=1}^{m} c_j \log X_j$$

where:

- Y = unit hydrograph characteristics
- b = regression constant
- c = regression coefficients
- X = physiographic and meteorological characteristics
- m = number of physiographic and meteorological characteristics selected

which in an equivalent form is:

$$Y = b X_1^{c_1} X_2^{c_2} \ldots X_m^{c_m}$$

28. Parameters initially selected as dependent variables were channel slope, drainage area, channel length, percent imperviousness, and effective rainfall duration. However, HEC concluded that channel length was closely related to drainage area and effective rainfall duration did not add significantly to the coefficient of determination.

29. Results of the regression analysis indicated that TC or (TC + R) could be defined best as a function of percent imperviousness (I), drainage area (DA) and channel slope (S).

TC = time from the end of effective rainfall to the inflection point on the recession limb of the direct-runoff hydrograph (in hours)

R = ratio of the discharge at the inflection point on the recession limb of the hydrograph to the rate of change of discharge at the same point (in hours)

I = percent impervious surface within a drainage area

DA = drainage area (in square miles)

S = average channel slope between the points 10 and 90 percent of the distance upstream from the gage or outflow point to the watershed boundary (in feet per mile).

30. A regional analysis was based on data taken from "Statistical Analysis of Hydrograph Characteristics for Small Urban Watersheds" Tracor, Inc., Tracor Document T 73-Au 9559, October 1973, on seven streams in the eastern United States. These seven streams were:

| | D.A. (sq. mi.) | L (mi.) | S (ft./mi.) | I (%) |
|---|---|---|---|---|
| Northwest Branch Anacostia River near Colesville, Md. | 21.30 | 17.2 | 23.0 | 6.3 |
| Walton Run, Phila, Pa | 2.17 | 2.8 | 25.7 | 24.7 |
| Pennypack Creek @ Pine Road, Phila., Pa. | 37.9 | 11.4 | 17.5 | 8.1 |
| Wooden Bridge Run, Phila., Pa. | 3.35 | 3.7 | 21.6 | 22.1 |
| Northeast Branch Anacostia River near Riverdale, Md. | 72.8 | 16.2 | 16.9 | 2.7 |
| Poquessing Creek at Trevose Road, Phila., Pa. | 5.1 | 3.5 | 33.9 | 12.5 |
| Wissahickon Creek @ Bells Mill Road, Phila., Pa. | 53.6 | 16.7 | 12.0 | 16.3 |

31. Several different forms of the regression were tested. Results of the four best correlations are shown in Table E-11. The second form of the equation shown in Table E-12 is very similar to the adopted equation for the sub-basin unit hydrography characteristic (TC + R) except that channel slope is defined differently. Running the regression analysis with data derived from the Dutton Mill Road gage resulted in the four equations shown in Table E-12.

32. Using the first and third equations of Table E-12 and assuming that both DA and S remain constant with time, then

TABLE E-11
RESULTS OF MULTIPLE REGRESSION ANALYSIS
ON A REGIONAL BASIS
CHESTER CREEK BASIN

$(K = 1.0 + 0.30\,I)$

| Equation | Standard Error of Estimate | Correlation Coefficient $\bar{R}$ | Coefficient of Determination $\bar{R}^2$ |
|---|---|---|---|
| $TC{+}R = 19.34\,K^{-0.64}\left(\frac{DA}{S}\right)^{0.23}$ | 0.0719 | 0.9569 | 0.9209 |
| $TC{+}R = 7.30\left(\frac{DA}{S}\right)^{0.32}$ | 0.1374 | 0.8431 | 0.7108 |
| $TC = 12.53\,K^{-0.67}\left(\frac{DA}{S}\right)^{0.25}$ | 0.0362 | 0.9909 | 0.0819 |
| $TC = 4.55\left(\frac{DA}{S}\right)^{0.35}$ | 0.1290 | 0.8771 | 0.7693 |

TABLE E-12
RESULTS OF MULTIPLE REGRESSION ANALYSIS
WHICH INCLUDED REGIONAL AS WELL AS
CHESTER CREEK BASIN DATA*

$(K = 1.0 + 0.30\,I)$

| Equation | Standard Error of Estimate | Correlation Coefficient $\bar{R}$ | Coefficient of Determination $\bar{R}^2$ |
|---|---|---|---|
| $(TC{+}R) = 17.01\,K^{-0.56}\left(\frac{DA}{S}\right)^{0.24}$ | 0.0818 | 0.9367 | 0.8775 |
| $(TC{+}R) = 7.56\left(\frac{DA}{S}\right)^{0.33}$ | 0.1228 | 0.8508 | 0.7239 |
| $(TC) = 11.54\,K^{-0.61}\left(\frac{DA}{S}\right)^{0.27}$ | 0.0811 | 0.9477 | 0.8981 |
| $(TC) = 4.78\left(\frac{DA}{S}\right)^{0.36}$ | 0.1286 | 0.8624 | 0.7437 |

* Unit hydrograph characteristics from the 1950, 1955, 1960 and 1969 flood hydrograph reconstitutions (taken from the preliminary Chester Creek report) were used in the analysis.

$$\frac{(TC + R)_{future}}{(TC + R)_{existing}} = \left(\frac{1.0 + 0.30\ I_{existing}}{1.0 + 0.30\ I_{future}}\right)^{0.56}$$

and

$$\frac{(TC)_{future}}{(TC)_{existing}} = \left(\frac{1.0 + 0.30\ I_{existing}}{1.0 + 0.30\ I_{future}}\right)^{0.61}$$

These equations were used to compute revised TC and R values that were used in the HEC-1 model to generate estimates of peak discharges for future land use patterns. Assumptions of unchanging main channel slopes are reasonable when considering the rolling terrain of the Basin; trends toward preventing structural development in the flood plain; and trends toward leaving natural stream environment unchanged.

## MODEL MODIFICATION TO REFLECT URBANIZATION

33. In addition to modifying existing unit hydrograph characteristics to reflect future urbanization, it was also necessary to adjust the variable RTIMP (portion of Basin that is impervious) as used in the original HEC-1 model. In studying existing conditions, RTIMP was set equal to zero and loss rates were optimized accordingly in the various flood hydrograph reconstitutions. For future land use and imperviousness projections, it was necessary to adjust the actual value of RTIMP to compensate for the fact that RTIMP was not initialized for existing conditions. The following relationship was tested by comparing results from selected sub-basins where an existing RTIMP was used to obtain a peak discharge and compared with one obtained from an unadjusted future condition RTIMP. The following equation was adopted to adjust the sub-basin percent imperviousness index derived from land use projections as previously described:

$$\left(RTIMP_{adjusted\ future}\right) = \frac{I_{future} - I_{existing}}{100 - I\ existing}$$

RTIMP is expressed as a decimal ratio and I is expressed in percent. These adjusted RTIMP values were included in the HEC-1 model along with projected changes in TC and R to obtain estimates of peak discharges for projected future land use patterns.

## GOOSE CREEK URBANIZATION

34. About 90 percent of the Goose Creek watershed above the damage areas is developed. Because of this, a detailed hydrologic analysis of future urbanization was not conducted. No future changes in the hydrology of this upper portion of the Goose Creek watershed are expected.

## RESULTS

35. The percent of impervious surfaces of each sub-basin was computed for two future conditions and is presented in Table E-13 (full and limited growth projections). Plate E-13 shows graphically the rate of change in imperviousness for two selected portions of the Chester Creek watershed. The effect of urbanization (year 2020) on existing one-hour unit hydrographs is shown on Plate E-14 for sub-basins 1 and 7. For sub-basin 1, the peak discharge would be increased by 35% and the time of concentration reduced by 35%. For sub-basin 7 the peak discharge would be increased 60 to 80% and the time of concentration reduced 40 to 55%. Increases are attributable to the change in imperviousness as it affects TC, R and RTIMP. Peak discharges from each sub-basin and combining point were computed for designated futures. For comparison, a tabulation of results is presented in Tables E-14 and E-15. The results are shown graphically at two locations in Plate E-15.

36. As shown in Plate E-15 future urbanization has a relatively greater effect on the more frequent flood events. The percentage increase in the flood peak due to limited growth projections was computed for various recurrence intervals and summarized below for two locations; Chester Creek at the USGS gage and Chester Creek before the confluence with the West Branch. The variation of percentage increase with recurrence intervals is consistent with previous work done in this field.*

* "Magnitude and Frequency of Floods in New Jersey with Effects of Urbanization," Special Report 38, State of New Jersey, Department of Environmental Protection, Division of Water Resources, 1974.

Epsey, W.H., Jr., and Winslow, D.E., "Urban Flood Frequency Characteristics," Journal of the Hyd. Div., Amer. Soc. Civil Eng., (HYD2), 279-293, February 1974.

Hollis, G.E., "The Effect of Urbanization on Floods of Different Recurrence Interval," Water Resources Research, Amer. Geo. Union, Vol. 11, 431-435, June 1975.

TABLE E-13
IMPERVIOUSNESS FOR
FULL AND LIMITED GROWTH
(IN PERCENT)

FULL GROWTH

| Sub-basin Number | Historic 1940 | Existing 1970 | Projected 1980 | Projected 1990 | Projected 2000 | Projected 2010 | Projected 2020 |
|---|---|---|---|---|---|---|---|
| 1 | 3 | 14 | 22 | 32 | 38 | 40 | 42 |
| 2 | 1 | 6 | 10 | 14 | 17 | 21 | 22 |
| 3 | 6 | 16 | 20 | 26 | 31 | 33 | 35 |
| 4 | 2 | 5 | 8 | 12 | 15 | 16 | 16 |
| 5 | 1 | 6 | 12 | 15 | 17 | 20 | 23 |
| 6 | 2 | 7 | 11 | 14 | 14 | 17 | 19 |
| 7 | 2 | 7 | 16 | 26 | 33 | 38 | 43 |
| 8 | 1 | 7 | 16 | 20 | 23 | 24 | 26 |
| 9 | 1 | 10 | 15 | 24 | 31 | 36 | 38 |
| 10 | 4 | 22 | 27 | 31 | 34 | 36 | 39 |
| 11 | 3 | 14 | 20 | 25 | 29 | 32 | 34 |
| 12 | 3 | 18 | 24 | 27 | 29 | 32 | 34 |
| 13 | 22 | 40 | 45 | 49 | 52 | 54 | 56 |
| 14 | 39 | 43 | 49 | 54 | 57 | 58 | 59 |

LIMITED GROWTH

| Sub-basin Number | Historic 1940 | Existing 1970 | Projected 1980 | Projected 1990 | Projected 2000 | Projected 2010 | Projected 2020 |
|---|---|---|---|---|---|---|---|
| 1 | 3 | 14 | 18 | 23 | 28 | 32 | 36 |
| 2 | 1 | 6 | 11 | 16 | 19 | 19 | 19 |
| 3 | 6 | 16 | 18 | 21 | 25 | 27 | 28 |
| 4 | 2 | 5 | 6 | 8 | 9 | 10 | 11 |
| 5 | 1 | 6 | 8 | 9 | 10 | 11 | 12 |
| 6 | 2 | 7 | 8 | 15 | 18 | 22 | 26 |
| 7 | 2 | 7 | 13 | 17 | 20 | 22 | 24 |
| 8 | 1 | 7 | 11 | 15 | 16 | 18 | 20 |
| 9 | 1 | 10 | 14 | 19 | 23 | 25 | 27 |
| 10 | 4 | 22 | 32 | 36 | 37 | 38 | 38 |
| 11 | 3 | 14 | 16 | 19 | 21 | 24 | 26 |
| 12 | 3 | 18 | 21 | 26 | 33 | 41 | 41 |
| 13 | 22 | 40 | 37 | 39 | 41 | 43 | 46 |
| 14 | 39 | 43 | 44 | 44 | 46 | 46 | 51 |

## TABLE E-14
## 2020 URBANIZATION (Full Growth Projection)
## COMPUTED PEAK DISCHARGFS AT VARIOUS STREAM LOCATIONS FOR HYPOTHETICAL FLOODS

| Description of Stream Location | Drainage Area (sq. mi.) | SPF | 100-Year | 25-Year | 10-Year | 2-Year |
|---|---|---|---|---|---|---|
| Chester Creek @ Confluence with East Branch (Sub-basins 1, 2 and 3 combined) | 19.76 | 19.990 | 12,000 | 8,110 | 6,150 | 3,090 |
| Chester Creek @ Hillis Road (Sub-basin 4) | 26.20 | 20,680 | 11,610 | 7,560 | 5,630 | 2,790 |
| Chester Creek before Confluence with West Branch (Sub-basin 1 through 5) | 35.94 | 22,580 | 12,280 | 7,880 | 5,750 | 2,850 |
| West Branch @ Markham (Sub-basins 6 and 7 combined) | 9.83 | 12,410 | 8,010 | 5,620 | 4,300 | 2,130 |
| Green Creek before Confluence with West Branch (Sub-basin 9) | 4.16 | 5,730 | 3,880 | 2,620 | 2,060 | 1,080 |
| West Branch @ Confluence with Green Creek (Sub-basins 6, 7, 8 and 9) | 17.34 | 19,670 | 12,430 | 8,380 | 6,460 | 3,270 |
| West Branch before Confluence with Chester Creek (Sub-basins 6 through 10) | 19.10 | 20,810 | 12,830 | 8,700 | 6,650 | 3,340 |
| Chester Creek @ Confluence with West Branch (Sub-basins 1 through 10) | 55.04 | 41,080 | 24,300 | 15,910 | 11,940 | 5,850 |
| Chester Creek @ USGS Gage (Sub-basins 1 through 11) | 61.1 | 41,000 | 24,000 | 15,280 | 11,500 | 5,710 |
| Chester Creek @ Confluence with Baldwin Run (Sub-basins 1 through 12) | 64.5 | 36,220 | 20,740 | 13,250 | 9,850 | 4,960 |
| Chester Creek @ Highway 95 (Sub-basins 1 through 13) | 66.0 | 32,800 | 18,680 | 11,900 | 8,810 | 4,480 |
| Mouth of Chester Creek (Sub-basins 1 through 14) | 67.9 | 30,300 | 17,280 | 11,000 | 8,130 | 4,170 |

## TABLE E-15
## 2020 URBANIZATION (Limited Growth Projection)
## COMPUTED PEAK DISCHARGES AT VARIOUS STREAM LOCATIONS FOR HYPOTHETICAL FLOODS

| Description of Stream Location | Drainage Area (sq. mi.) | SPF | 100-Year | 25-Year | 10-Year | 2-Year |
|---|---|---|---|---|---|---|
| Chester Creek @ Confluence with East Branch (Sub-basins 1, 2 and 3 combined) | 19.76 | 19,460 | 11,580 | 7,580 | 5,670 | 2,690 |
| Chester Creek @ Hillis Road (Sub-basin 4) | 26.20 | 20,570 | 11,590 | 7,370 | 5,410 | 2,500 |
| Chester Creek before Confluence with West Branch (Sub-basin 5) | 35.94 | 23,480 | 12,860 | 8,000 | 5,760 | 2,550 |
| West Branch @ Markham (Sub-basins 6 and 7 combined) | 9.83 | 12,480 | 8,170 | 5,620 | 4,240 | 1,990 |
| Green Creek before Confluence with West Branch (Sub-basin 9) | 4.16 | 5,550 | 3,560 | 2,490 | 1,870 | 880 |
| West Branch @ Confluence with Green Creek (Sub-basins 6, 7, 8 and 9) | 17.34 | 19,270 | 12,150 | 7,860 | 5,960 | 2,790 |
| West Branch before Confluence with Chester Creek (Sub-basins 6 through 10) | 19.01 | 20,620 | 12,740 | 8,360 | 6,270 | 2,940 |
| Chester Creek @ Confluence with West Branch (Sub-basins 1 through 10) | 55.04 | 40,250 | 23,940 | 14,980 | 11,050 | 4,970 |
| Chester Creek @ USGS Gage (Sub-basins 1 through 11) | 61.1 | 40,930 | 23,840 | 14,970 | 10,840 | 4,910 |
| Chester Creek @ Confluence with Baldwin Run (Sub-basins 1 through 12) | 64.5 | 36,030 | 20,690 | 12,850 | 9,230 | 4,270 |
| Chester Creek @ Highway 95 (Sub-basins 1 through 13) | 66.0 | 32,340 | 18,520 | 11,450 | 8,190 | 3,840 |
| Mouth of Chester Creek (Sub-basins 1 through 14) | 67.9 | 29,730 | 17,060 | 10,520 | 7,520 | 3,550 |

| | At USGS Gage (Sub-basins 1 thru 11) | At Confluence (Sub-basins 1 thru 5) |
|---|---|---|
| 2-Year | 63% | 42% |
| 10-Year | 34 | 21 |
| 25-Year | 26 | 14 |
| 50-Year | 19 | 11 |
| 100-Year | 17 | 8 |
| 500-Year | 14 | 9 |

A more detailed breakdown by decades of the discharge-frequency at the two locations is shown on Plate F-16. These discharge-frequency curves, Plate E-16, represent limited growth rate projections only. This type of data was used in the economic (benefit) analyses.

## RESULTS OF GOOSE CREEK ANALYSIS

37. Discharge-frequency curves at four index locations at Goose Creek damage areas were developed from the HEC-1 model output. These locations are at Cedar and Franklin Streets, Union Street railroad culvert, Lacy Street, and Linden Street and are shown on Plate E-12 as nodal point Numbers 106, 104, 103 and 101, respectively. The following tabulation gives the calculated flows at these locations for the three flood events analyzed as well as estimated flows for the 50-year event. Plate F-17 illustrates the discharge-frequency functions for the four locations along Goose Creek.

| Location (Nodal Point) | Frequency 100-Year | 50-Year | 25-Year | 10-Year |
|---|---|---|---|---|
| Ceder & Franklin Sts. (#106) | 708 | 620 | 536 | 434 |
| Union St. Railroad Culvert (#104) | 480 | 420 | 327 | 284 |
| Lacy Street (#103) | 449 | 390 | 348 | 299 |
| Linden Street (#101) | 480 | 415 | 366 | 311 |

## COMPARISON WITH OTHER STUDIES

38. After the hydrologic studies were completed in December 1976 nine Department of Housing and Urban Development (HUD) Flood Insurance studies (FIS) which have been conducted in the Chester Creek Basin were reviewed to determine if there were any differences in discharge-frequency estimates used for the studies. Where there were differences, an effort was made to account for the reasons for the differences. Results from these HUD studies are compared with the results of the Chester Creek Basin study in Table F-16.

TABLE E-16
COMPARISON WITH OTHER STUDIES
HYDROLOGY AND HYDRAULICS
CHESTER CREEK BASIN

| Location | Drainage Area 1/ | Study 2/ | Discharge in cfs 3/ | |
|---|---|---|---|---|
| | | | 10-Year | 100-Year |
| Sub-basin 1 | 8.1 sq. mi. | CC | 1,900 | 4,590 |
| | | BETZ | 2,040 | 5,100 |
| Sub-basins 1 through 3 | 19.8 sq. mi. | CC | 4,100 | 9,700 |
| | | SCS. | 5,100 | 10,500 |
| Sub-basins 1 and 2 | 11.7 sq. mi. | CC | 2,700 | 6,000 |
| | | SCS | 2,900 | 6,300 |
| | | BETZ | 2,360 | 5,900 |
| Sub-basin 7 | 4.9 sq. mi. | CC | 1,220 | 2,830 |
| | | SCS | 1,100 | 2,700 |
| Sub-basin 9 | 4.2 sq. mi. | CC | 1,290 | 2,820 |
| | | SCS | 1,100 | 2,300 |
| Sub-basins 6 and 7 | 9.8 sq. mi. | CC | 2,540 | 5,830 |
| | | SCS | 2,100 | 4,700 |
| USGS Gage 1 through 11 | 61.1 sq. mi. | CC | 8,100 | 21,000 |
| | | BETZ | 8,000 | 20,000 |
| | | MBE | 7,400 | 15,000 |
| West Chester Nodal pt. #106 | 1.1 sq. mi. | CC | 434 | 708 |
| | | BETZ | 535 | 1,130 |

1/ Drainage area in square miles (sq. mi.).
2/ The hydrologic studies which were compared are:

CC = Metropolitan Chester Creek Basin Study.
SCS = Federal Flood Insurance Studies for Concord and Thornbury Townships, Delaware County, by the Soil Conservation Service
BETZ = Federal Flood Insurance Studies for Communities in the Chester Creek Basin by Betz Environmental Engineers, Plymouth Meeting, Pennsylvania (1977).
MBE = Federal Flood Insurance Study for Brookhaven Borough, by Michael Baker Engineers (1974), updated by Dewberry, Nealon and Davis Consulting Engineers (1975).
3/ Discharges in Cubic feet per second (cfs).

39. These differences are the result of using different procedures and in the adopted parameters. Also in the recent studies, adjusted expected probabilities were used to make the estimates. Most are considered minor. One exception is the Brookhaven FIS report which uses a 100-year discharge of 15,000 cfs. A statisical analysis of observed data verifies the 2,100 cfs used in this study. Also, the comparison in West Chester revealed considerable differences in flow above the confluence of Goose Creek with East Branch Goose Creek. Below the confluence the 50-year flow agreed quite well (1580 cfs vs. Betz flow of 1640 cfs). The primary reason for the larger differences further upstream in the Basin is that the Betz model was designed to evaluate a much larger area than just West Chester. This fact tends to limit the accuracy of the Betz model in the upper reaches.

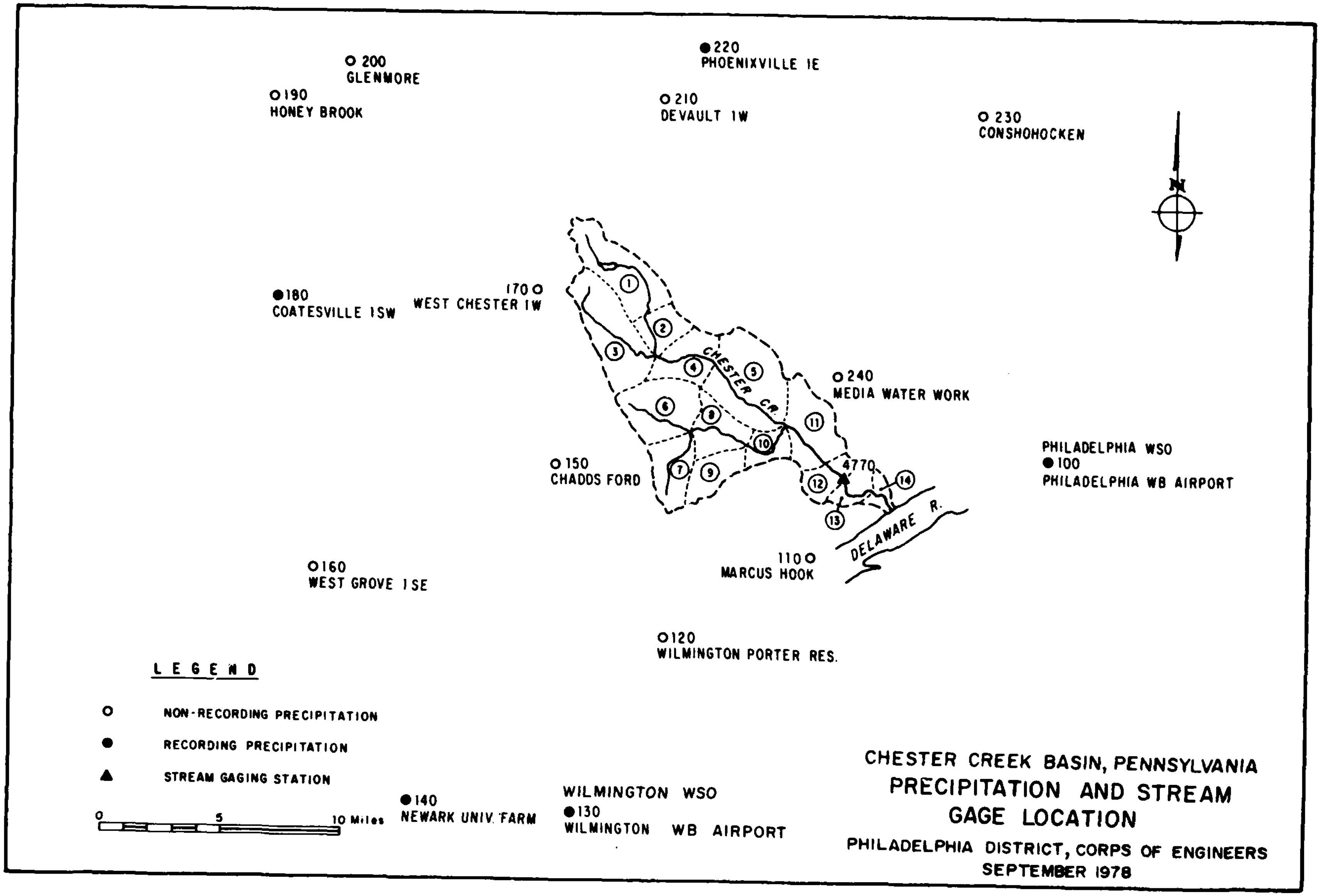
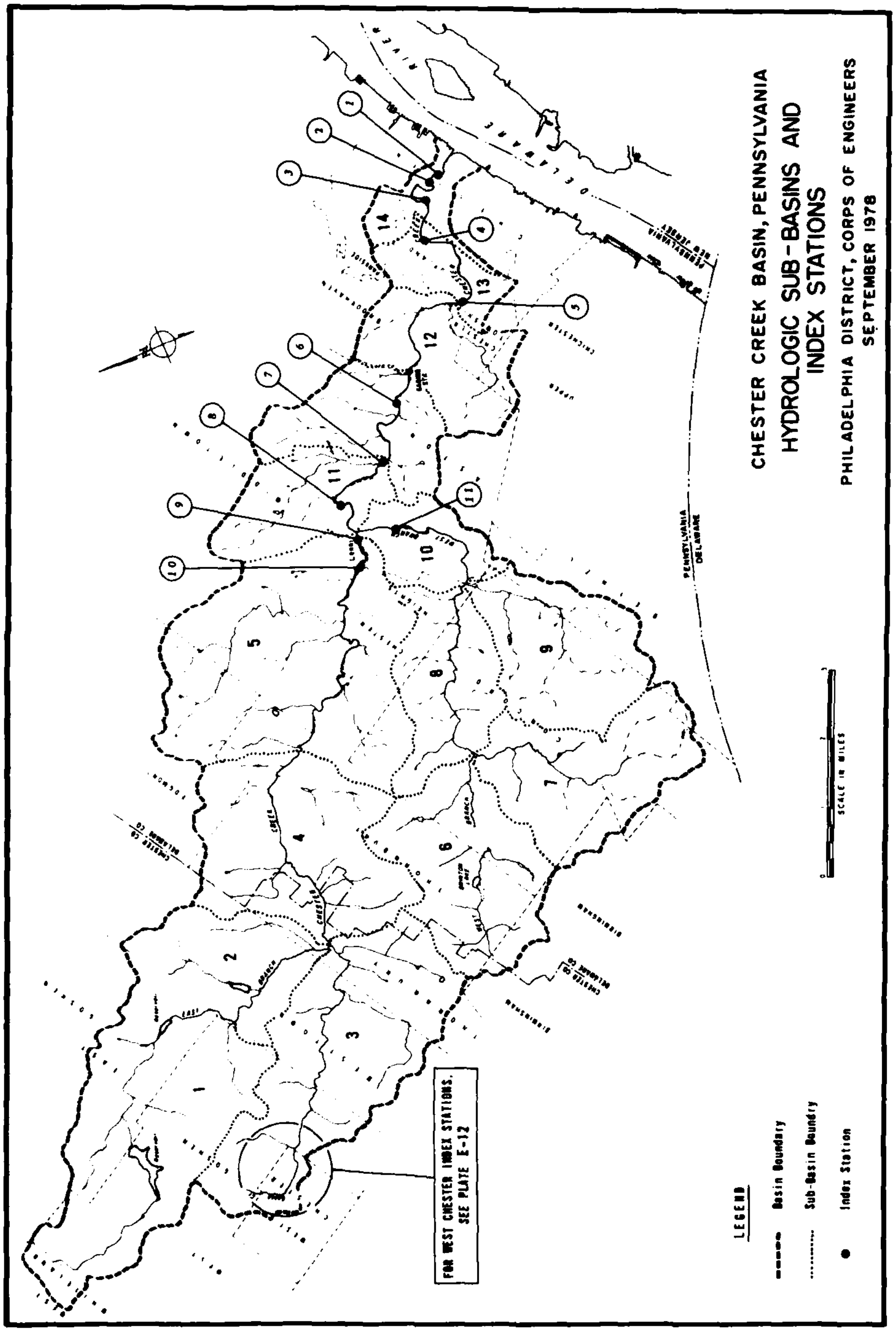
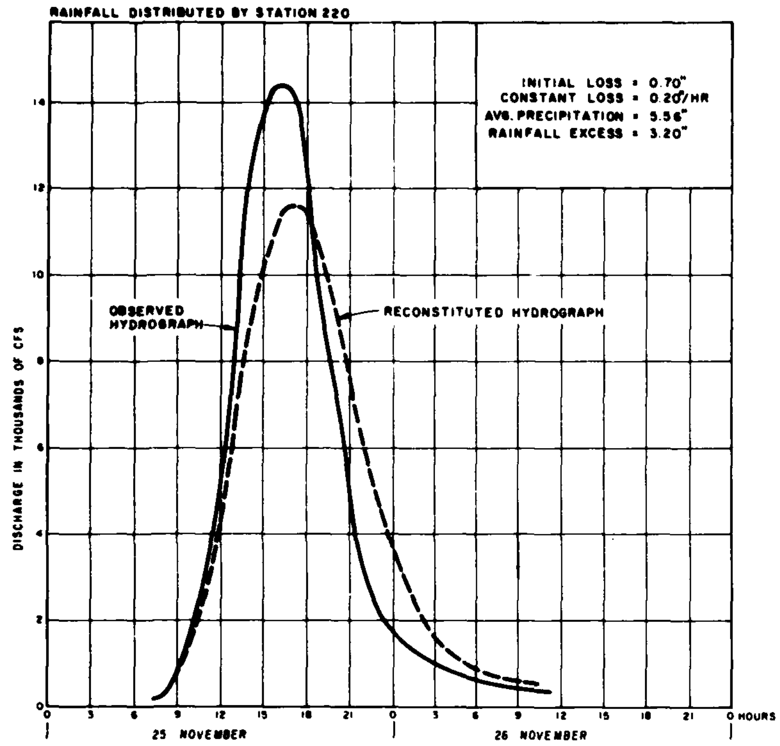

O 200
GLENMORE
O 190
HONEY BROOK
● 220
PHOENIXVILLE 1E
O 210
DEVAULT 1W
O 230
CONSHOHOCKEN
N
● 180
COATESVILLE 1SW
170 O
WEST CHESTER 1W
CHESTER CR.
O 240
MEDIA WATER WORK
PHILADELPHIA WSO
● 100
PHILADELPHIA WB AIRPORT
O 150
CHADDS FORD
4770
DELAWARE R.
O 160
WEST GROVE 1SE
110 O
MARCUS HOOK
O 120
WILMINGTON PORTER RES.
LEGEND
NON-RECORDING PRECIPITATION
RECORDING PRECIPITATION
STREAM GAGING STATION
0
5
10 Miles
● 140
NEWARK UNIV. FARM
WILMINGTON WSO
● 130
WILMINGTON WB AIRPORT
CHESTER CREEK BASIN, PENNSYLVANIA
PRECIPITATION AND STREAM
GAGE LOCATION
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE E-1

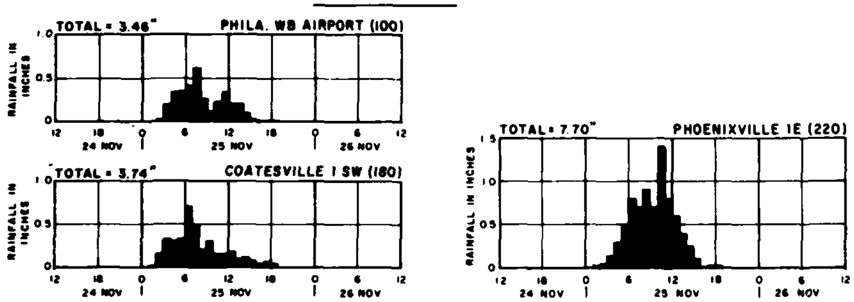


CHESTER CREEK BASIN, PENNSYLVANIA
HYDROLOGIC SUB-BASINS AND INDEX STATIONS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978
LEGEND
Basin Boundary
Sub-Basin Boundary
Index Station
FOR WEST CHESTER INDEX STATIONS, SEE PLATE E-12
SCALE IN MILES
PENNSYLVANIA
DELAWARE
DELAWARE
RIVER

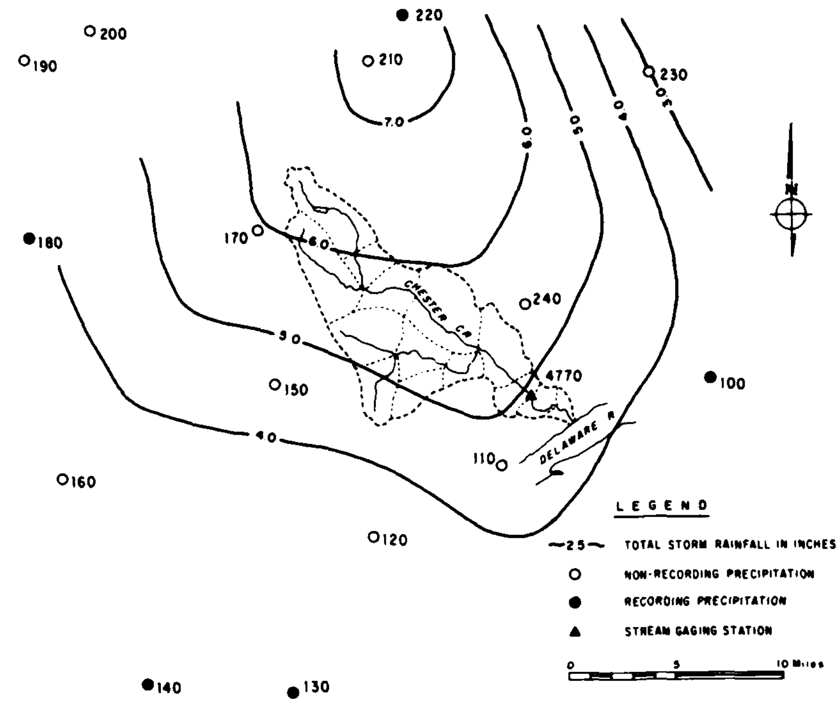

PLATE E-2




HYDROGRAPHS



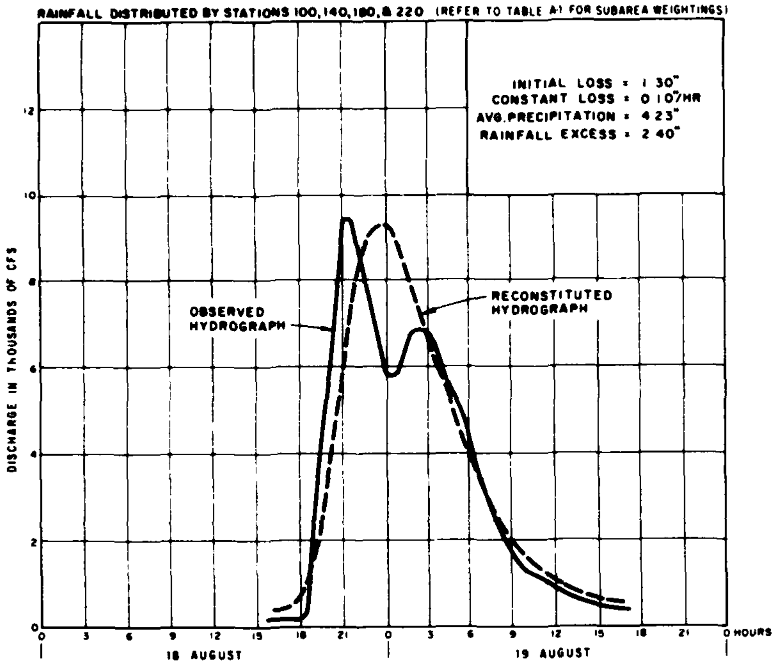

HYETOGRAPHS



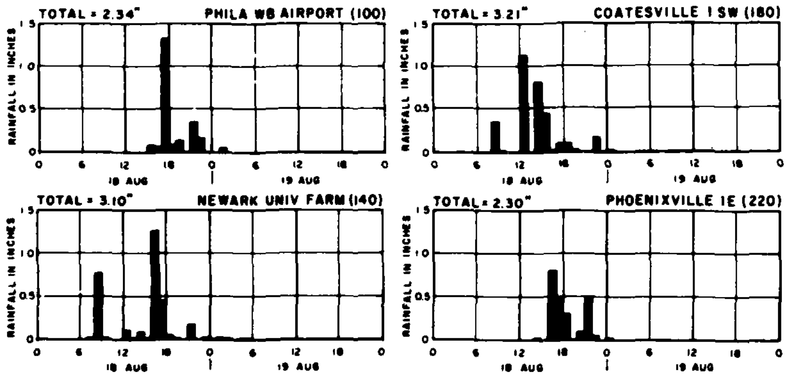

ISOHYETAL MAP

CHESTER CREEK BASIN, PENNSYLVANIA
STORM OF
25 - 26 NOVEMBER 1950
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

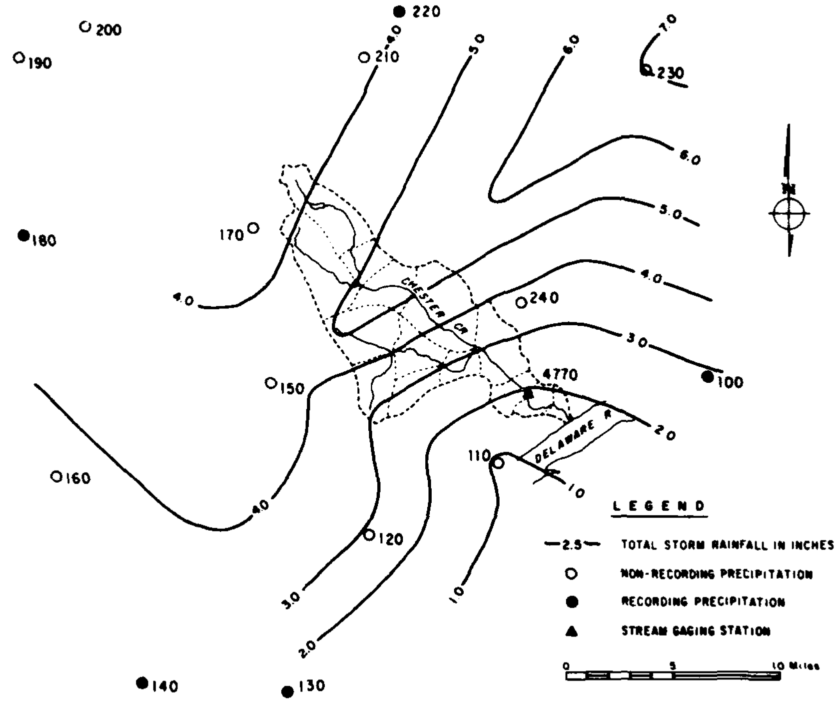
PLATE E-3




HYDROGRAPHS



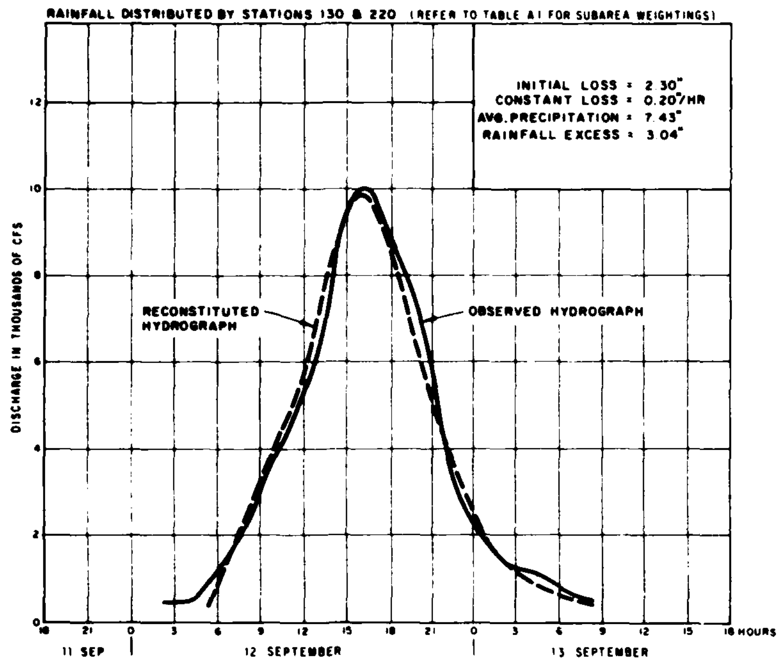

HYETOGRAPHS



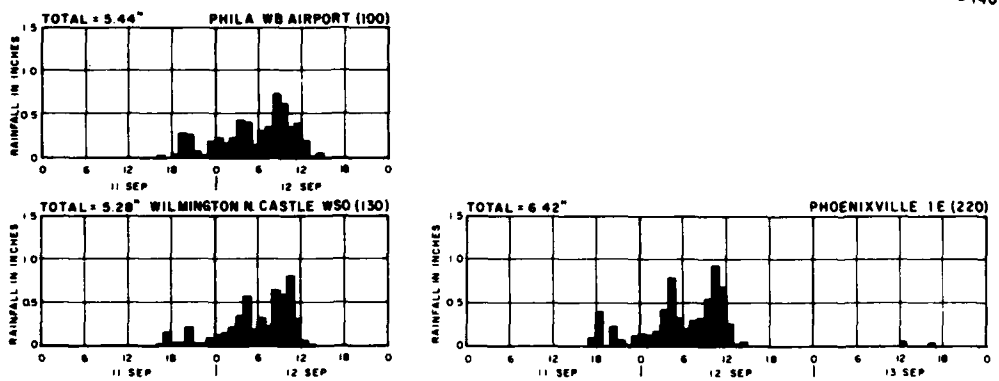

ISOHYETAL MAP

CHESTER CREEK BASIN, PENNSYLVANIA
STORM OF
18 - 19 AUGUST 1955
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

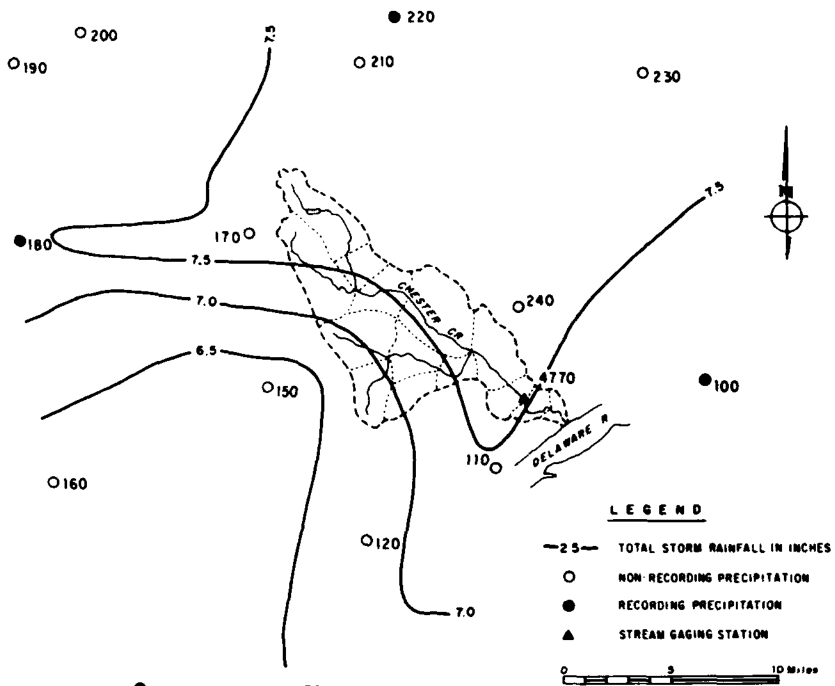
PLATE E-4




HYDROGRAPHS




HYETOGRAPHS




ISOHYETAL MAP

CHESTER CREEK BASIN, PENNSYLVANIA

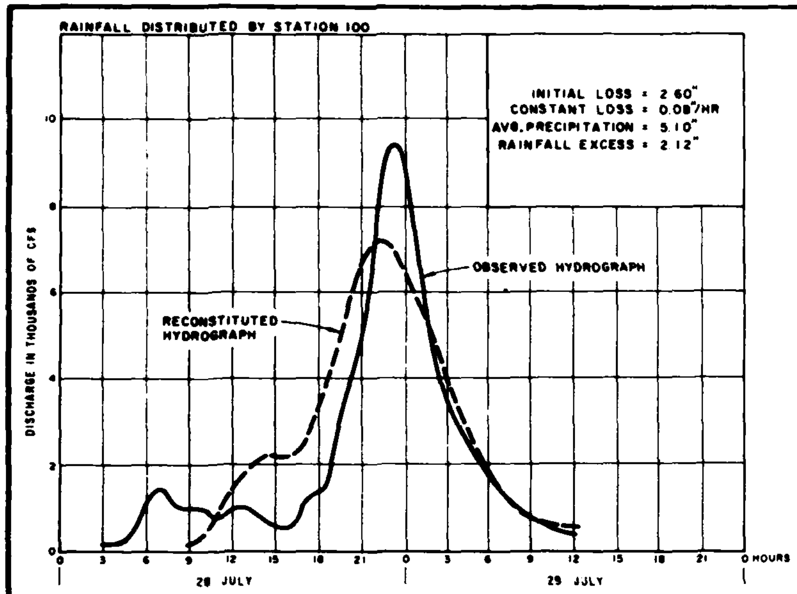
STORM OF

11 - 13 SEPTEMBER 1960

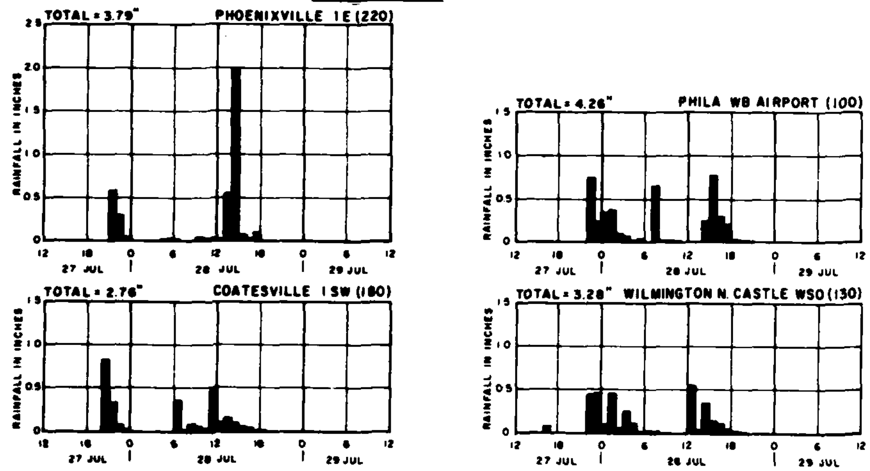
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

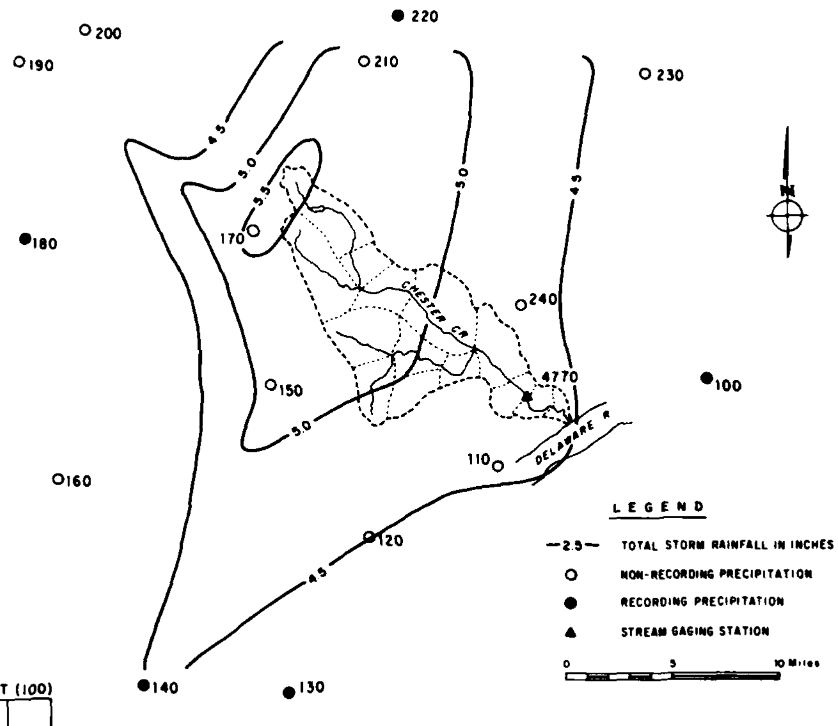
PLATE E-5




HYDROGRAPHS

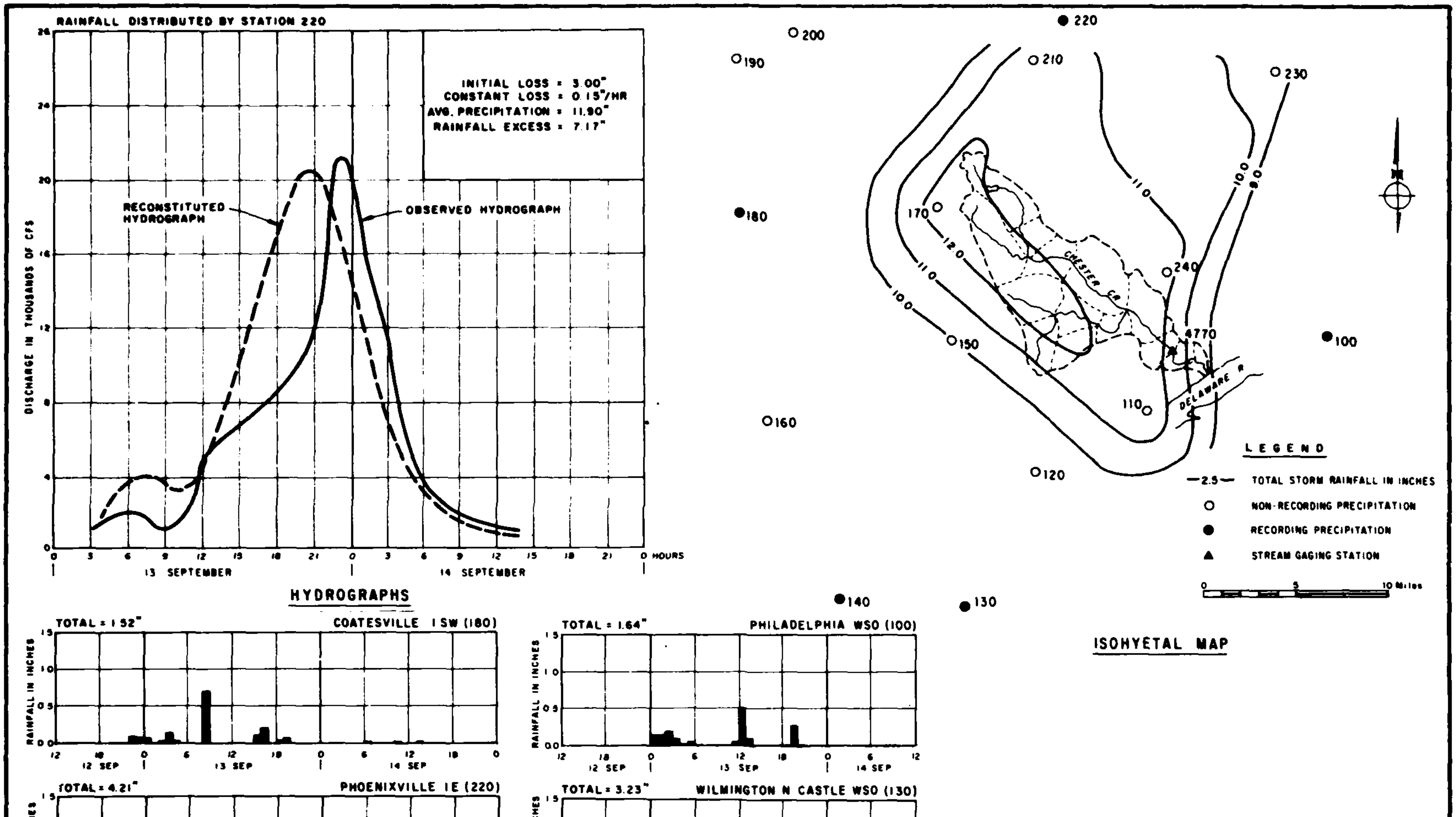



HYETOGRAPHS



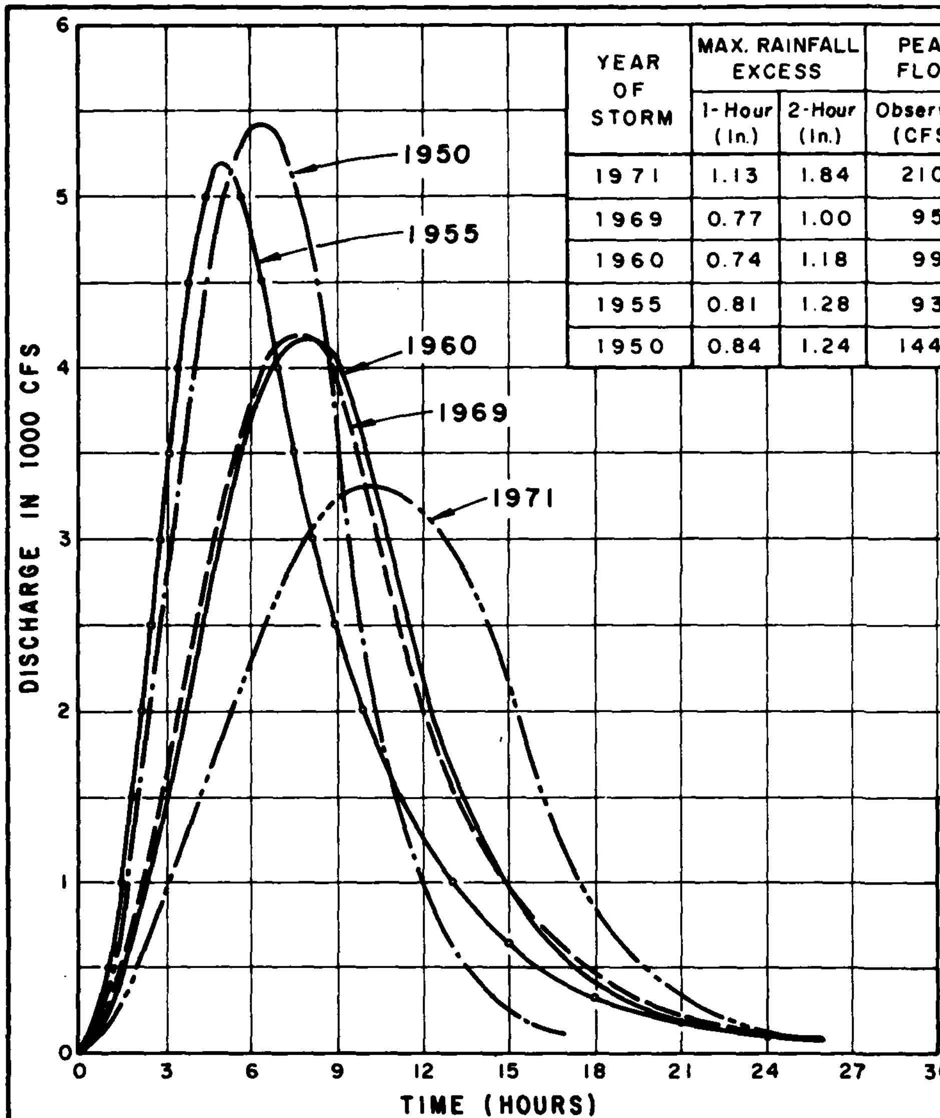

ISOHYETAL MAP

CHESTER CREEK BASIN, PENNSYLVANIA
STORM OF
27 - 28 JULY 1969
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978




CHESTER CREEK BASIN, PENNSYLVANIA
STORM OF
12 - 14 SEPTEMBER 1971
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE E-7



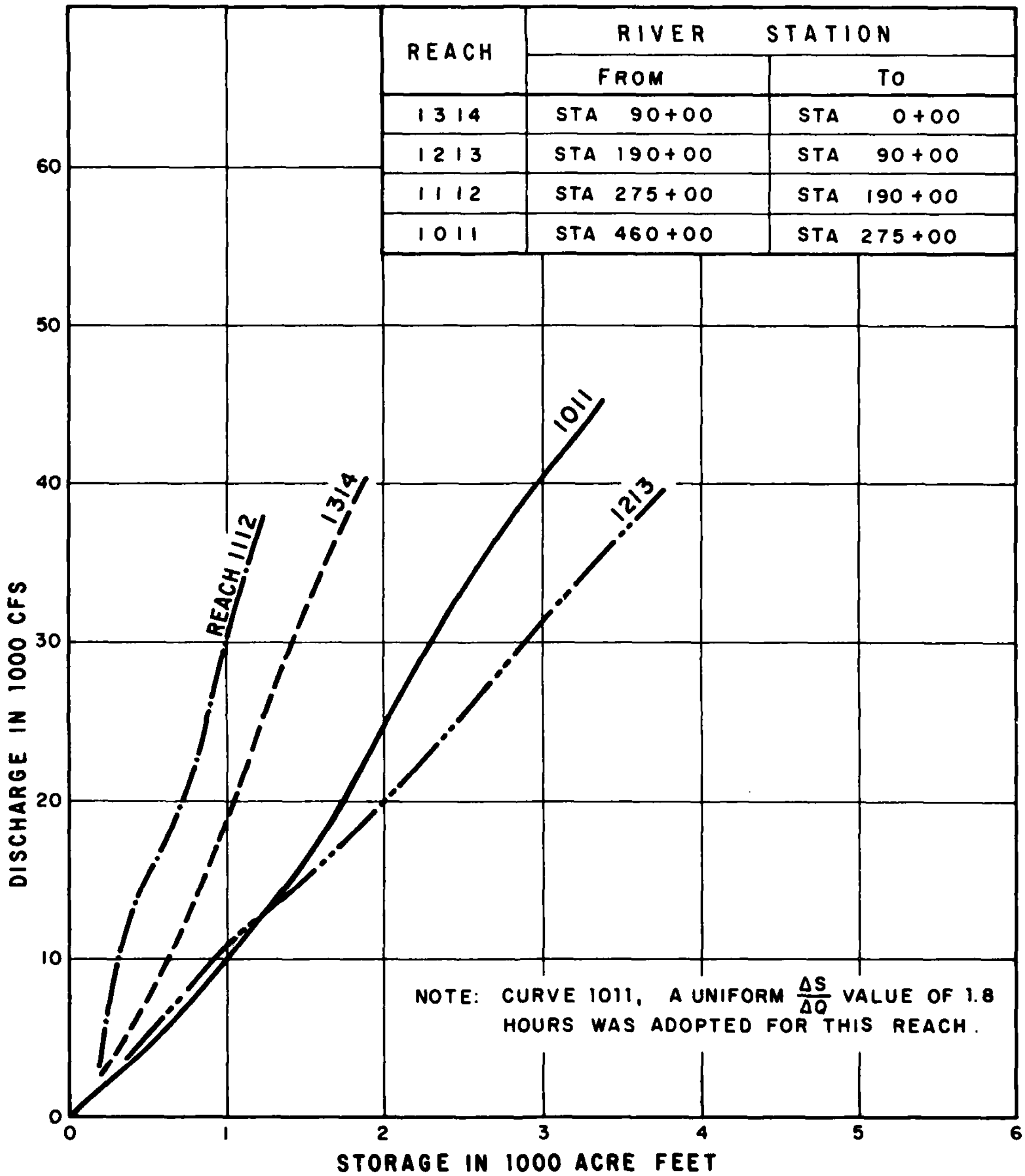

| YEAR OF STORM | MAX. RAINFALL EXCESS | | PEAK FLOW | TC | R | $\frac{R}{TC+R}$ | Tp | Cp | RAINFALL LOSSES | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1-Hour (In.) | 2-Hour (In.) | Observed (CFS) | (Hrs.) | (Hrs.) | | (Hrs.) | | Initial (In.) | Const. (In./Hr.) |
| 1971 | 1.13 | 1.84 | 21000 | 14.5 | 3.2 | 0.18 | 10.0 | 0.83 | 1.74 | 0.21 |
| 1969 | 0.77 | 1.00 | 9560 | 9.1 | 4.1 | 0.31 | 7.2 | 0.75 | 2.49 | 0.07 |
| 1960 | 0.74 | 1.18 | 9940 | 9.8 | 3.7 | 0.27 | 7.5 | 0.78 | 0.85 | 0.17 |
| 1955 | 0.81 | 1.28 | 9380 | 5.3 | 4.4 | 0.45 | 4.7 | 0.62 | 1.37 | 0.09 |
| 1950 | 0.84 | 1.24 | 14400 | 8.3 | 2.9 | 0.26 | 6.0 | 0.82 | 1.30 | 0.17 |

CHESTER CREEK BASIN, PENNSYLVANIA

OPTIMIZED 1-HOUR UNIT HYDROGRAPHS
(5 FLOODS)

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE E-8

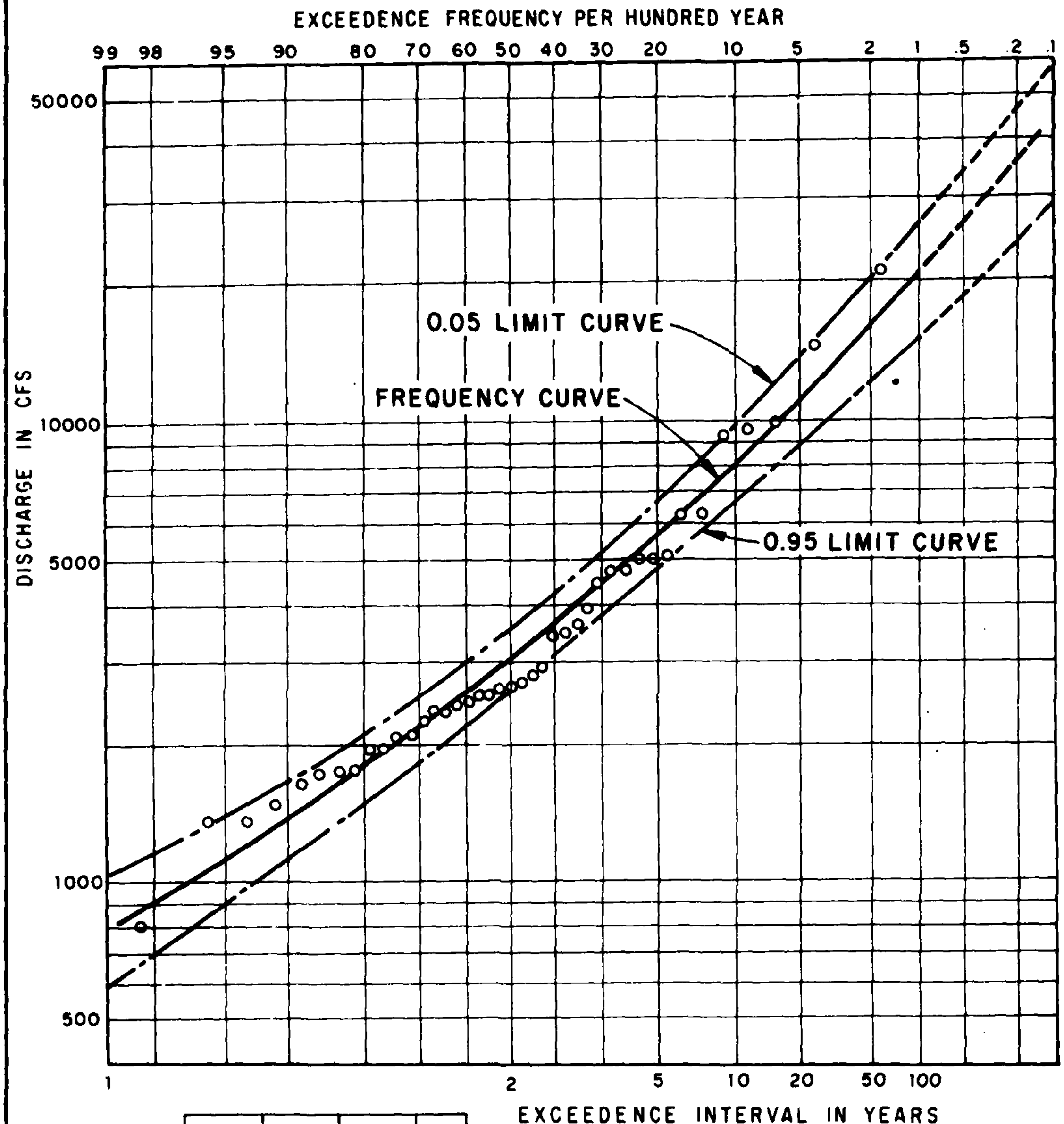



| REACH | RIVER STATION | |
|---|---|---|
| | FROM | TO |
| 1314 | STA 90+00 | STA 0+00 |
| 1213 | STA 190+00 | STA 90+00 |
| 1112 | STA 275+00 | STA 190+00 |
| 1011 | STA 460+00 | STA 275+00 |

CHESTER CREEK BASIN, PENNSYLVANIA

STORAGE DISCHARGE
CHESTER CREEK

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978




| | Mean | Standard Deviation | Skew Coefficient | Period of Record |
|---|---|---|---|---|
| 1932-72 | 3.506 | 0.296 | 0.758 | 41 |
| 1902-72 | 3.507 | 0.295 | 0.553 | 65 |
| ADOPTED | 3.507 | 0.295 | 0.400 | 65 |

DRAINAGE AREA ABOVE U.S.G.S. GAGE = 61.1 SQ. MILES

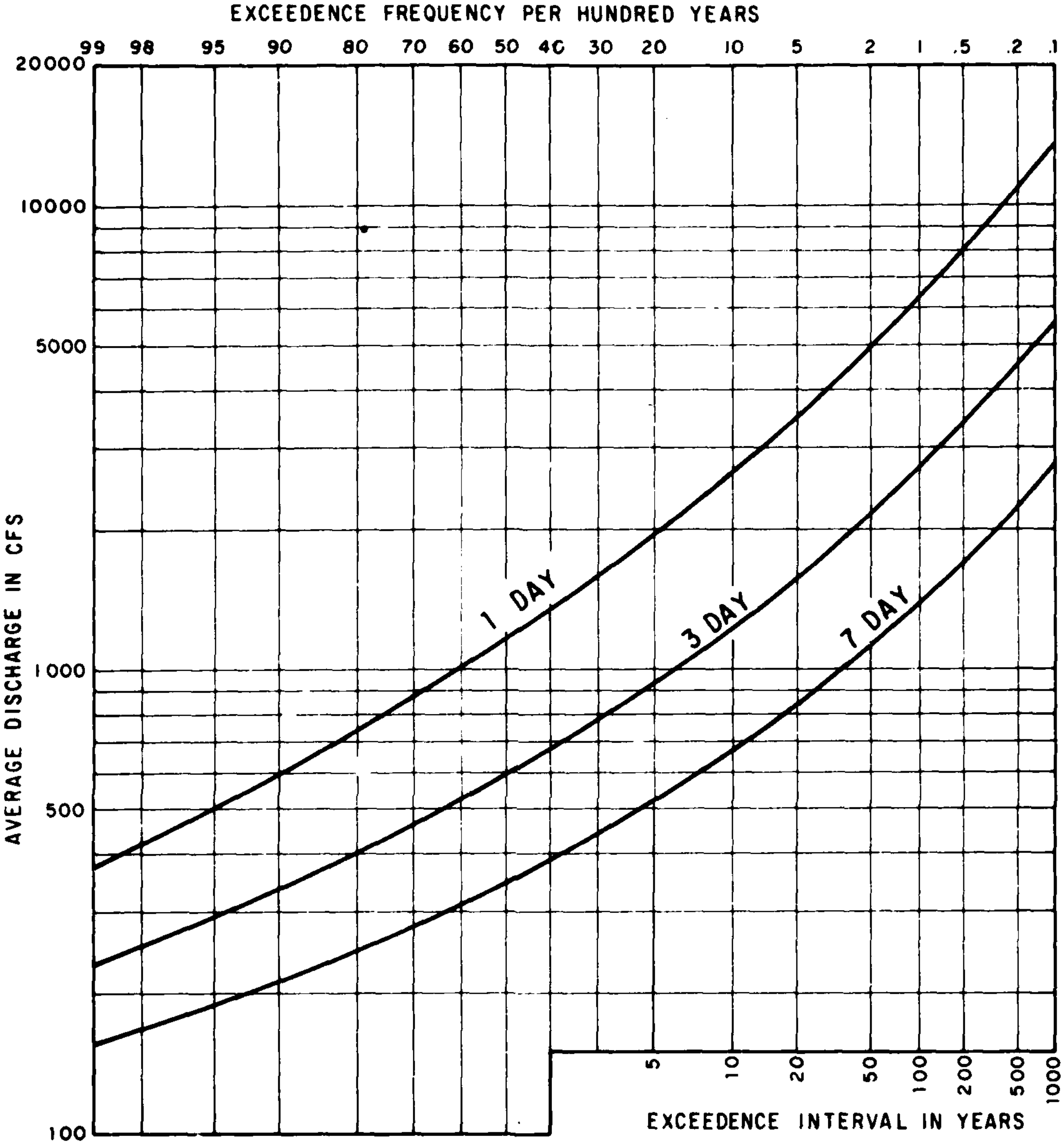
GAGE AT DUTTON MILL ROAD

CHESTER CREEK BASIN, PENNSYLVANIA

## DISCHARGE - FREQUENCY U.S.G.S. GAGE

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978



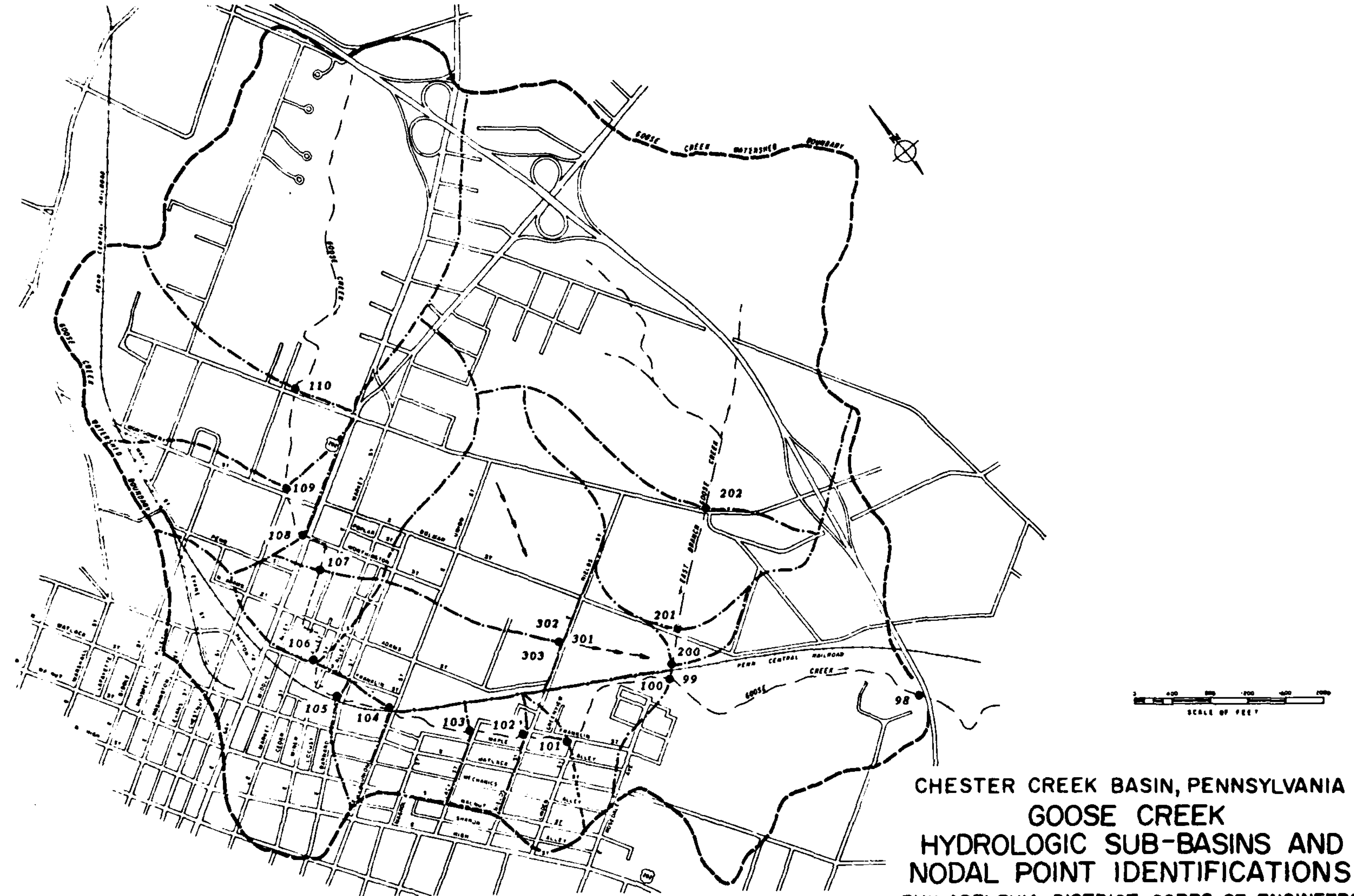

NOTE: DRAINAGE AREA ABOVE U.S.G.S. GAGE = 61.1 SQ. MILES.

CHESTER CREEK BASIN, PENNSYLVANIA

## MAXIMUM RUNOFF VOLUME - FREQUENCY
## USGS GAGE

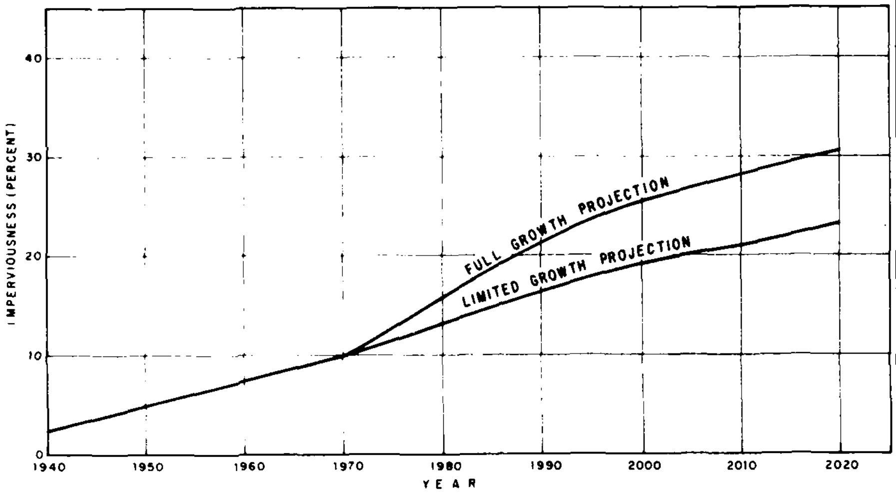
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE E-11

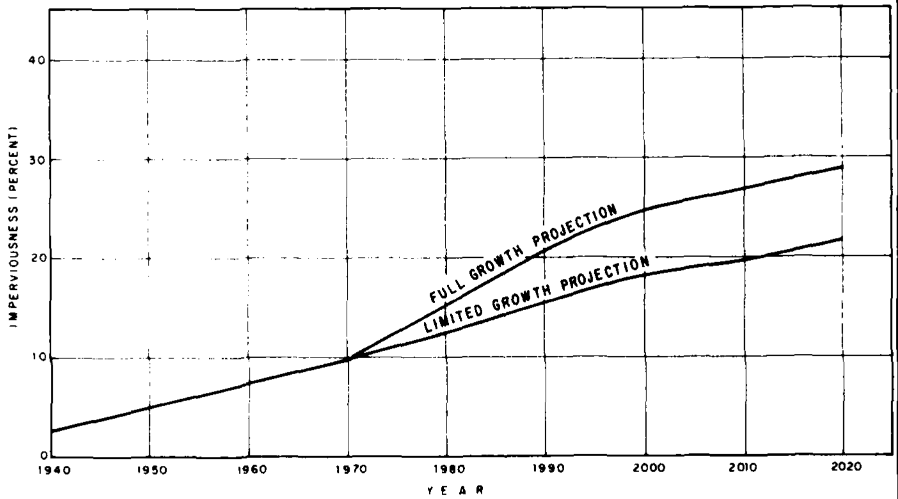



CHESTER CREEK BASIN, PENNSYLVANIA
GOOSE CREEK
HYDROLOGIC SUB-BASINS AND
NODAL POINT IDENTIFICATIONS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE E-12




SUB-BASINS 1 THROUGH 11



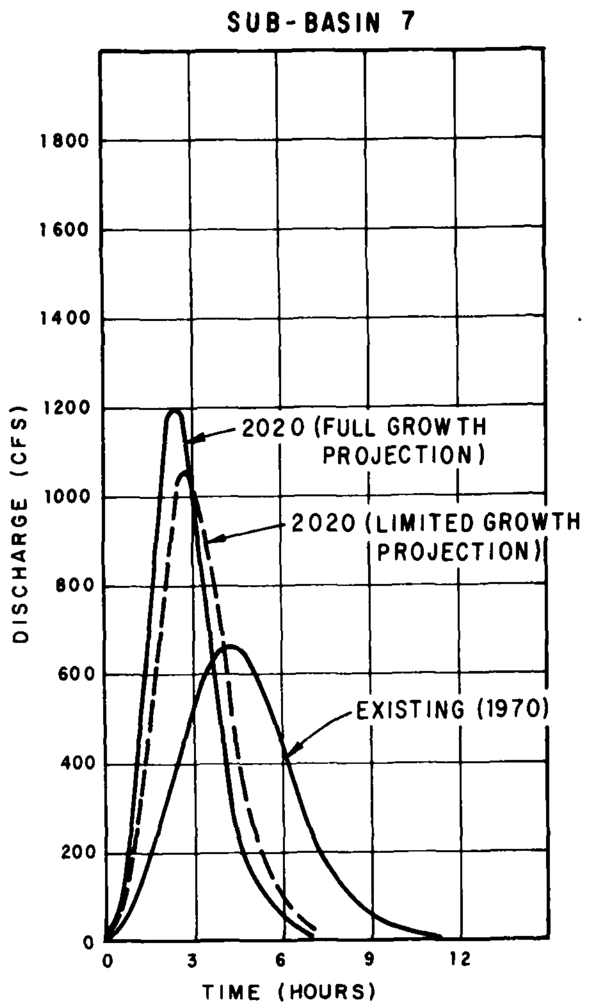

SUB-BASINS 1, 2, 3, 4, & 5

CHESTER CREEK BASIN, PENNSYLVANIA

## PER CENT IMPERVIOUSNESS VS TIME

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE E-13




1 HOUR UNIT HYDROGRAPHS

DRAINAGE AREAS:

SUB-BASIN 1 = 8.40 sq. mi.

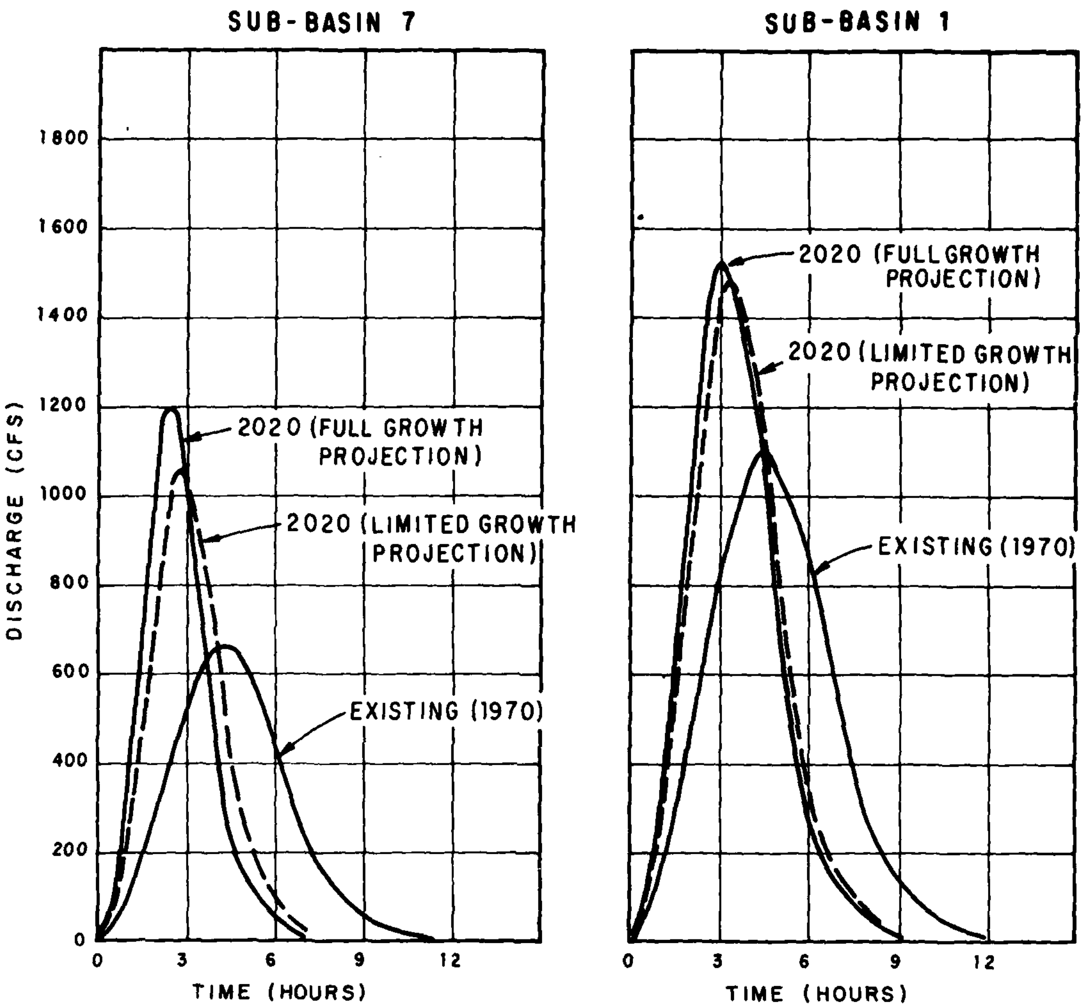
SUB-BASIN 7 = 4.91 sq. mi.

CHESTER CREEK BASIN, PENNSYLVANIA

EFFECT OF URBANIZATION ON
I HOUR UNIT HYDROGRAPH

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE E-14




1 HOUR UNIT HYDROGRAPHS

DRAINAGE AREAS:

SUB-BASIN 1 = 8.40 sq. mi.

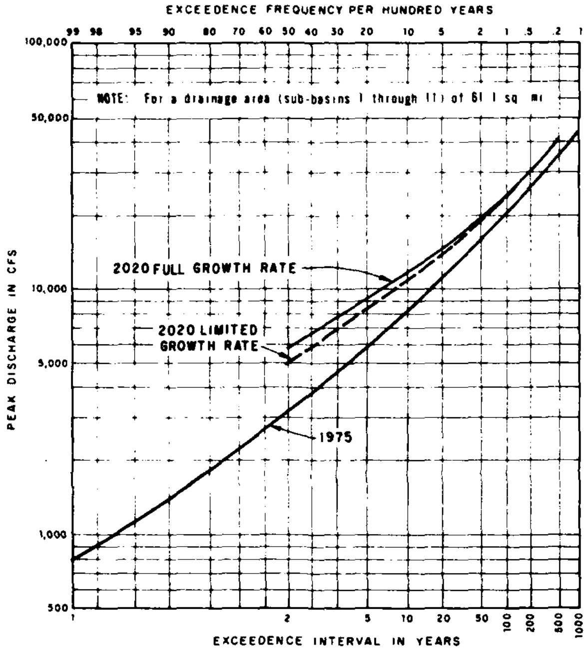
SUB-BASIN 7 = 4.91 sq. mi.

CHESTER CREEK BASIN, PENNSYLVANIA

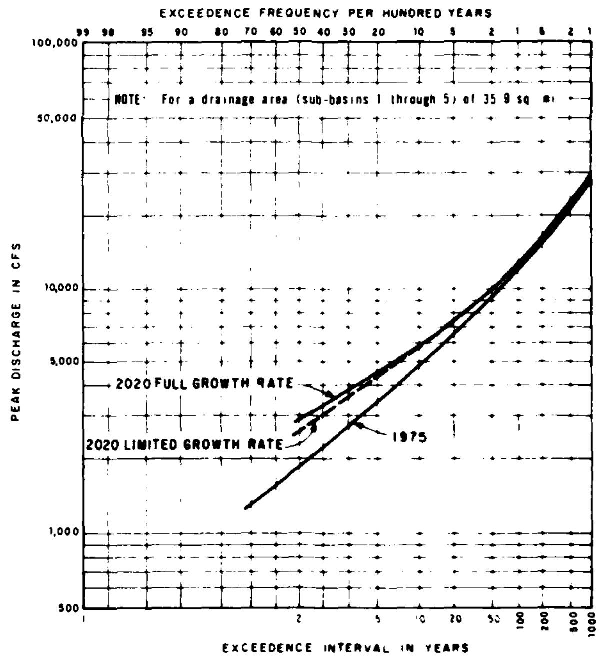
**EFFECT OF URBANIZATION ON 1 HOUR UNIT HYDROGRAPH**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE E-14




CHESTER CREEK AT U.S.G.S. GAGE 1/




WEST BR. CHESTER CR. 2/

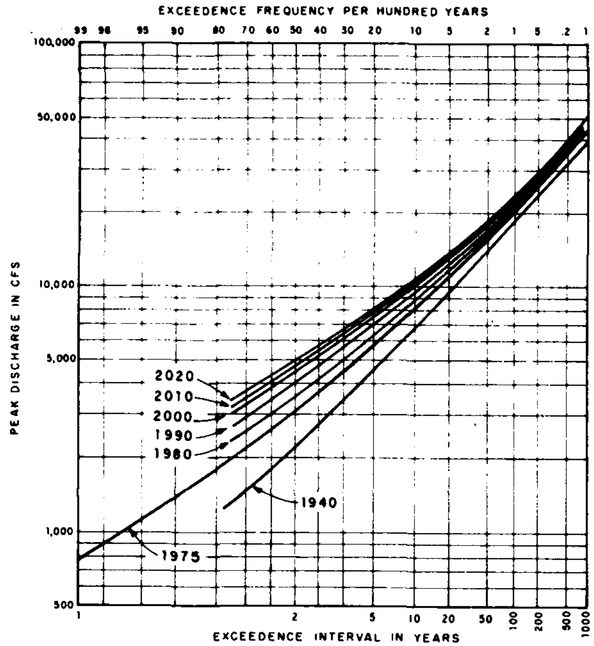
NOTES

1/For USGS stream gage at Dutton Mill Rd.
2/For West Branch before the confluence with main stem Chester Creek

CHESTER CREEK BASIN, PENNSYLVANIA

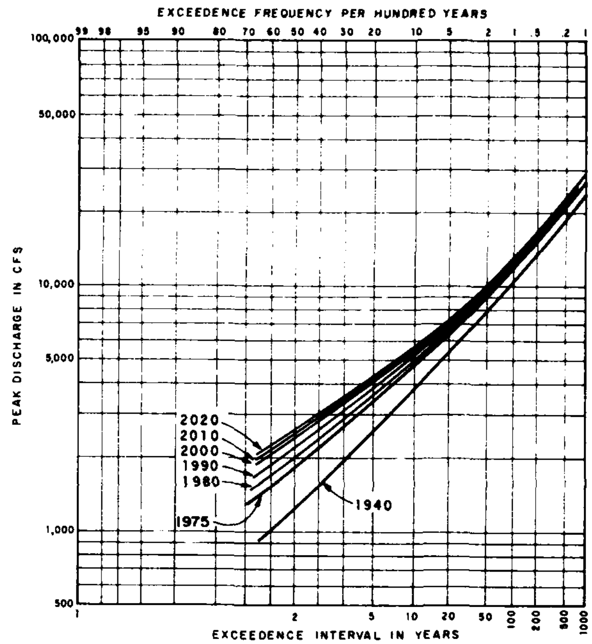
# COMPARISON OF GROWTH RATE ON DISCHARGE - FREQUENCY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978




CHESTER CREEK AT U.S.G.S. GAGE 1/

NOTE: For a drainage area (sub-basins 1 through 11) of 61.1 sq. mi.




WEST BR. CHESTER CR. 2/

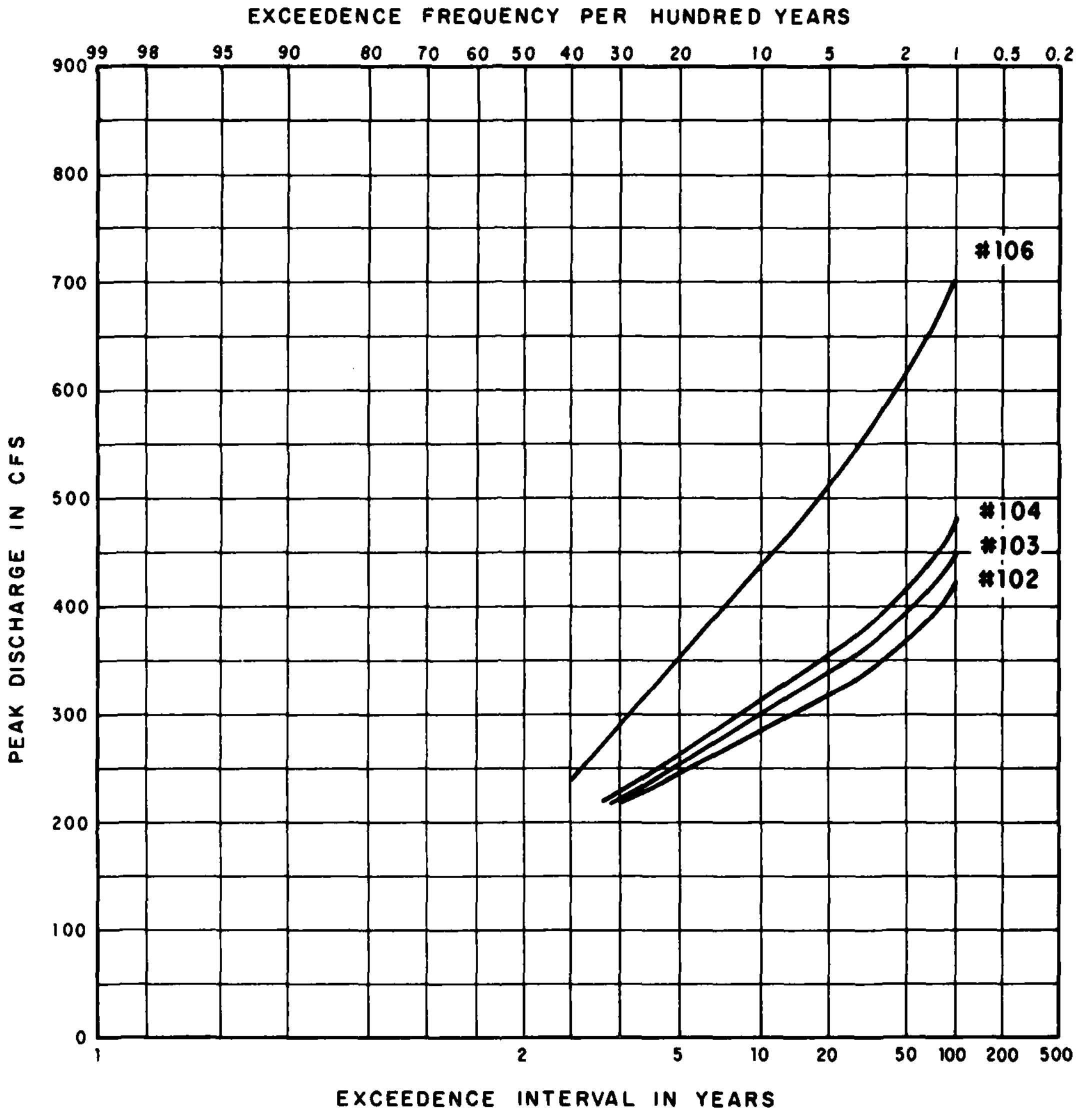
NOTE: For a drainage area (sub-basins 1 through 5) of 35.9 sq. mi.

NOTES
1/ For USGS stream gage at Dutton Mill Rd.
2/ For West Branch before the confluence with main stem Chester Creek

CHESTER CREEK BASIN, PENNSYLVANIA

DISCHARGE-FREQUENCY
LIMITED GROWTH PROJECTIONS

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978




**NOTE:** #XXX are nodal point numbers.

CHESTER CREEK BASIN, PENNSYLVANIA

DISCHARGE-FREQUENCY CURVES AT VARIOUS LOCATIONS ALONG GOOSE CREEK

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

SECTION F

# HYDRAULIC STUDIES

1. Hydraulic studies were conducted to determine the extent of existing flooding problems in the Basin, to evaluate the reduction in flood peaks for various flood control measures, and to estimate the effects that future development in the Basin could have on the flood problem and flood control measures.

2. Detailed studies were done only for the major damage reaches in the Basin.* These were located in two areas—Chester Creek from the Delaware River to the Baltimore Pike (U.S. Route 1) and Goose Creek in West Goshen Township and the Borough of West Chester. This section describes the methodology, assumptions, procedures and results of the hydraulic studies.

## LOWER CHESTER CREEK BASIN

3. This sub-section describes hydraulic studies for damage reaches 1 through 18 in the Lower Chester Creek Basin. This includes hydraulic model development; flood of record simulation; stage-discharge information; and flood plain characteristics relevent to the hydraulic studies.

### MODEL DEVELOPMENT

4. Computer program 723-X6-L202A, HEC-2 Water Surface Profiles was used for hydraulic modeling. A computer model of about 53,800 feet of stream channel, 26 bridges, and 2 small dams was developed for main stem Chester Creek; and 3,400 feet of stream channel, 4 bridges and 2 small dams for the West Branch. Many sources of existing data were utilized to determine cross sections, Manning "n" values, and bridge and dam

* Major damage reaches were defined as reaches with great enough damages to potentially justify individual flood control measures. The major damage reaches are 1-18 in the lower part of the Basin and 51-55 in the Goose Creek Watershed.

information required as input for the model. The major sources were previous Corps studies, Flood Insurance Studies, topographic mapping by USGS and Delaware County, aerial photographs, high water marks from USGS, and survey data collected by the Corps and others.

5. Much of this information required modification before it was usable as input data. Many of the available cross sections had to be extended to reflect the overbank flooding that occurs at the higher flows. Several sections, especially in the areas where buildings are adjacent to streambanks, had to be modified to reflect the overbank blockage of flow. Where cross sectional survey data was lacking or substantial changes in flow direction occurred due to river bends, additional sections were added by utilizing all the available information. One hundred and fourteen cross sections were inputed into the HEC-2 model.

## HISTORIC FLOOD VERIFICATION

6. Discharge information for the study reaches was developed as discussed in Appendix 1, Section E. The following flow rates were utilized as input for the September 1971 storm simulation:

<u>Chester Creek</u>

| | |
|---|---|
| Sta. 7+30 to 285+00 | 21,000 cfs (flow from sub-basins 1-11) |
| Sta. 285+00 to 460+70 | 20,000 cfs (flow from sub-basins 1-10) |
| Sta. 460+70 to 537+94 | 12,000 cfs (flow from sub-basins 1-5) |

<u>West Branch Chester Creek</u>

| | |
|---|---|
| Sta. 0+00 to 33+90 | 8,000 cfs (flow from sub-basin 6-10) |

The location of reaches can be found from the stationing information shown on Plates F-1 through F-7. The locations of the sub-basins were discussed in Section F.

7. Mannings "n" values were chosen for the channel (.03 to .07) and overbank (.06 to .10) flows by correlating field inspections with aerial photos. Since many existing bridges were overtopped in 1971, the special bridge routine in HEC-2 was utilized in order to evaluate associated pressure-weir flow combinations. The coefficients of expansion and contraction used were .3 and .1, respectively. These values are the normally accepted values for gradual transitions. These losses can be higher at bridges (0.5 to 0.3); however, since the special bridge routine was used in the model, during flood flows most bridge routines revert to a pressure flow-weir flow conditions regardless of the coefficients used. The Mannings "n" values were adjusted and refined along the Creek to provide the simulated profile shown on Plates F-1 through F-7. The energy grade line profile (EGL), which represents the

elevation corresponding to the depth of flow plus the velocity head ($V^2/2g$), is also shown to reflect the possible degree of high-water mark variations. Theoretically, the high-water marks at locations with negligible flow velocities can be as high as the EGL.

8. The computed water surface profiles were in reasonable agreement with the recorded high-water marks (Table C-1) as noted on Plates F-1 through F-7. Minor differences between computed and observed high-water marks are due to physical conditions in the Basin at the time of the flood (primarily blockage of bridge openings by debris and vegetation). It can be seen on the plates that these differences are not significant.

## STAGE-DISCHARGE INFORMATION

9. Once reasonable agreement was obtained between the computed profiles and recorded water surface profiles for the September 1971 flood, water surface profiles were computed for other flows. However, the Dutton Mill Road gage (USGS No. 4770) was the only location where the hydraulic model could be verified over a range of flows. Relatively minor adjustments to the Mannings "n" values for channel sections below the gage were made. This was done because the effective channel values decreased with depth over the range of flows. Plate F-8 includes the stage-discharge rating curve developed by the United States Geological Survey (USGS) and the computed stage-discharge curve at the gage location.

10. A tidal elevation of 6.0 feet above mean sea level datum (MSLD) was used as the starting elevation for all of the water surface profile computed on the Chester Creek except for SPF. For SPF 12.0 msld was used. The SPF tide at the City of Chester is 14 ft. Mean Sea Level Datum. However, as can be seen on the profiles presented on Plate F-9, the SPF fluvial profile would not be affected beyond 3rd Street regardless of the starting tidal elevation at the mouth. Computations were started at Sta. 7+30. This elevation was selected since it represents tailwater elevations which could occur during the flood season. This elevation is approximately the highest tide of the day during the flood of September 1971. This elevation has about a 50% exceedance frequency (two year event). Studies showed that the starting elevation had little effect on upstream water surface profiles, as the backwater effects of the many bridges in the City of Chester were the factors which most influenced the water surface elevation. This condition is readily illustrated in Plate F-1.

11. Eleven Index Stations were chosen to represent stage-discharge relationships for damage reaches. These Index Stations are shown on Plates F-9 through F-15. Multiple flow profiles were then run on the calibrated hydraulic model and stage-discharge information was determined at each of the eleven Index Stations. The 10, 50, 100-year, and Standard Project Flood profiles are shown on Plates F-9 through F-15. Left and right bank elevations shown on the profile sheets represent the approximate elevations where damages begin to occur. These are not streambank elevations. The 25-year flood profile was also computed but is not included on the plates.

AD-A106 781 ARMY ENGINEER DISTRICT PHILADELPHIA PA F/G 13/2
WATER RESOURCES STUDY FOR METROPOLITAN CHESTER CREEK BASIN, PEN--ETC(U)
SEP 78
UNCLASSIFIED DAEN/NAP-12000/WRS-78/09 NL

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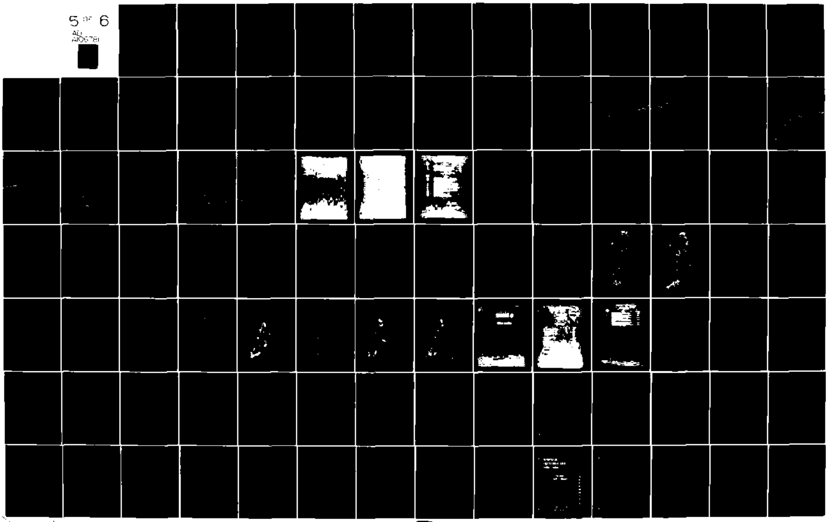


TABLE F-1
UNITED STATES GEOLOGICAL SURVEY
HIGH-WATER ELEVATIONS
(September 13, 1971 Flood)
CHESTER CREEK BASIN



| Reference Location and Station 1/ | Elevation 2/ and Location 3/ | Reference Location and Station 1/ | Elevation 2/ and Location 3/ | Reference Location and Station 1/ | Elevation 2/ and Location 3/ |
|---|---|---|---|---|---|
| CHESTER CREEK | | Walk Bridge | | Dutton Mill Bridge | 49.44, L.B. +80 |
| | | (Sproul Road) | 24.48, R.B. +50 | 276+00 | 49.80, R.B. +100 |
| 2nd Street Bridge | 8.42, L.B. -200 | 52+25 | 24.55, L.B. +125 | | 49.84, R.B. +120 |
| 9+40 | 8.13, R.B. -200 | | | | 52.40, R.B. +1700 |
| | 10.70, R.B. -100 | I-95 Bridge | 25.74, R.B. -150 | | |
| | 9.18, L.B. -70 | (Baltimore and Ohio | 25.28, L.B. -150 | Penn Central | 53.71, R.B. -80 |
| | 8.89, L.B. -60 | Railroad Bridge) | 25.24, L.B. +0 | Railroad Bridge | 53.60, R.B. -50 |
| | 11.69, L.B. +0 | 90+00 | 26.02, R.B. +300 | 304+60 | 53.10, R.B. -15 |
| | 9.99, L.B. +0 | | | | 54.53, R.B. +15 |
| | 11.77, R.B. +50 | Kerlin Street Bridge | 27.38, L.B. -40 | | 54.74, R.B. +30 |
| | | 108+90 | 27.68, R.B. +0 | | 56.14, R.B. +100 |
| 3rd Street Bridge | 12.72, L.B. -220 | | 27.31, L.B. +0 | | 55.84, R.B. +120 |
| 14+60 | 12.01, R.B. -200 | | 27.29, L.B. +75 | | 56.70, R.B. +200 |
| | 12.56, L.B. -150 | | | | 57.17, R.B. +220 |
| | 12.73, L.B. -70 | Upland Road Bridge | 28.72, R.B. -125 | | |
| | 13.85, R.B. -30 | 14+731 | 28.94, R.B. -100 | Knowlton Road Bridge | 58.65, R.B. -80 |
| | 13.73, L.B. +0 | | 28.80, R.B. -100 | 323+80 | 58.64, R.B. -40 |
| | | | 28.74, - - -41 | | 58.63, L.B. -30 |
| 5th Street Bridge | 16.70, R.B. -200 | | 29.02, R.B. +30 | | 60.14, R.B. +6 |
| 22+10 | 16.41, L.B. -25 | | 29.19, R.B. +30 | | 58.29, L.B. +10 |
| | 16.99, R.B. -10 | | 28.83, R.B. +100 | | 59.13, L.B. +100 |
| | 16.78, L.B. +30 | | 28.58, L.B. +200 | | 59.72, L.B. +180 |
| | 17.73, R.B. +125 | | 29.47, R.B. +1650 | | 61.09, L.B. +200 |
| | 18.27, R.B. +400 | | 29.39, R.B. +2050 | | 62.21, L.B. +1500 |
| | 18.22, R.B. +450 | | 30.05, R.B. +2335 | | |
| | | | 30.07, R.B. +2350 | Mt. Alverno Road Bridge | 64.16, L.B. -600 |
| 6th Street Bridge | 20.30, R.B. +0 | | 30.80, L.B. +2700 | 363+50 | 65.77, R.B. -150 |
| 29+50 | 20.41, R.B. +0 | | 31.29, L.B. +2900 | | 65.95, R.B. -100 |
| | 20.53, L.B. +200 | | | | 66.02, R.B. -75 |
| | | Bridgewater Bridge | 35.23, L.B. -1650 | | 66.17, R.B. -30 |
| 7th Street Bridge | 21.19, L.B. -60 | 232+60 | 35.02, R.B. -1600 | | 65.79, L.B. +0 |
| 33+80 | 22.01, R.B. -60 | | 38.12, R.B. -350 | | 66.80, R.B. +300 |
| | 21.81, R.B. +0 | | 38.39, R.B. -200 | | 67.85, L.B. +300 |
| | 21.53, L.B. +125 | | 38.36, L.B. -100 | | 67.70, L.B. +300 |
| | 23.02, R.B. +125 | | 39.81, R.B. +30 | | |
| | | | 39.66, L.B. +150 | | |
| 9th Street Bridge | 23.04, L.B. -50 | | 41.83, R.B. +500 | | |
| 45+80 | 23.13, R.B. -30 | | 45.69, R.B. +1313 | | |
| | 23.47, R.B. +0 | | | | |
| | 24.19, R.B. +250 | | | | |

## TABLE F-1 (Continued)



| Reference Location and Station 1/ | Elevation 2/ and Location 3/ | Reference Location and Station 1/ | Elevation 2/ and Location 3/ | Reference Location and Station 1/ | Elevation 2/ and Location 3/ |
|---|---|---|---|---|---|
| Pennsylvania Central Railroad Bridge 410+60 | 75.71, R.B. -350 | Convent Road Bridge 459+80 | 101.98, L.B. -400 | **WEST BRANCH** | |
| | 76.43, R.B. -300 | | 102.87, R.B. -300 | | |
| | 78.73, R.B. -270 | | 103.32, L.B. +75 | Convent Road Bridge 0+100 | |
| | 78.75, R.B. -220 | | 104.02, R.B. +150 | | 108.43, R.B. +600 |
| | 76.18, L.B. -120 | | | | |
| | 79.25, R.B. -100 | Hollow Hill Road Bridge 462+75 | 104.78, L.B. -140 | New Road Bridge 11+06 | 110.68, L.B. -100 |
| | 79.65, R.B. -30 | | 105.34, L.B. +0 | | 110.95, L.B. -50 |
| | 81.13, R.B. +20 | | 104.48, L.B. +200 | | 109.83, R.B. -50 |
| | 80.83, L.B. +70 | | 104.85, R.B. +200 | | 117.28, R.B. +60 |
| | 80.93, L.B. +120 | | | | |
| | | Lenni Road Bridge 488+00 | 109.40, R.B. -300 | Second Dam Above Mouth 23+90 | 127.17, R.B. -500 |
| Pennell Road Bridge 420+10 | 81.67, L.B. -350 | | 112.86, L.B. -100 | | 130.93, R.B. -350 |
| | 81.52, L.B. -300 | | 113.05, L.B. -80 | | 135.59, R.B. +0 |
| | 81.85, R.B. -70 | | 114.45, R.B. +40 | | 135.84, R.B. +50 |
| | 80.87, L.B. -50 | | 115.38, L.B. +150 | | 137.56, R.B. +200 |
| | 81.79, L.B. -30 | | | | 138.23, R.B. +230 |
| | 80.92, R.B. +150 | Pennsylvania Central Railroad Bridge 520+18 | | | |
| | 82.55, L.B. +150 | | 128.32, L.B. -400 | | |
| | | | 132.17, R.B. -125 | | |
| Pennsylvania Central Railroad Bridge 427+50 | 83.31, L.B. -225 | | | | |
| | 83.48, L.B. -150 | Baltimore Pipe Bridge 537+19 | 140.36, L.B. -10 | | |
| | 87.68, R.B. +50 | | 140.36, L.B. +20 | | |
| | 88.36, L.B. +70 | | 141.15, L.B. +300 | | |
| | 88.98, R.B. +100 | | 142.55, L.B. +970 | | |
| | 90.50, L.B. +200 | | | | |
| | 93.56, L.B. +800 | | | | |

1/ Reference stations are located at the upstream face of bridges.
2/ Elevation in feet above mean sea level.
3/ Locations of high-water elevations are keyed to reference stations. L.B. and R.B. are left and right banks, respectively, looking downstream. +200 indicates 200 feet upstream from reference station. -100 indicates 200 feet downstream from reference station.
4/ Railroad bridges are commonly referred to in the area by their old names even though they have been purchased in recent years by Conrail, Amtrak, and Chessie.

## FLOOD PLAIN CHARACTERISTICS

12. The approximate 25-year, 100-year, and SPF flood plains for the lower Chester Creek Basin are shown on Plate F-16. The HEC-2 program provided channel velocities for all streams modeled. At high flows the Creek is characterized by relatively high channel velocities until the flow approaches the Borough of Upland. Channel velocities drop off rapidly in the vicinity of Upland Road as shown on Plate F-17. This plate shows the average channel velocity conditions of Chester Creek below the Dutton Mill Road Gage. The average velocities of the 2-year and 100-year flows for existing conditions are shown. General velocity trends of channel flow are shown by drawing in the velocity profiles using a graphical "best fit" approach.

13. The flatter thalweg gradient and lower velocities between Ninth Street and Kerlin Street can be attributed to two probable factors. First, the tidal effect for the Delaware extends just upstream of the Kerlin Street Bridge, causing a substantial reduction in velocities even at low flows and thereby causing sediments to be dropped out in that vicinity. The second factor is impedance to high flows by bridges and roadway embankments at both the Ninth Street and Kerlin Street locations. These obstructions back up flow, reduce incoming velocities and allow sediment deposition.

14. A review of the five highest flows recorded at the Dutton Mill gage provides some insight into the flow characteristics of the lower Chester Creek Basin. The flood hydrographs were previously presented in Section E and are shown on Plates E-3 through E-7. The flow of 4,000 cfs has an exceedence interval of approximately three years at the gage and is significant in that it is about the flow that overbank damages begin to occur. Durations above this flow for the five major storms ranged from 6 to 18 hours with an average of about 11 hours. The rise in stage at the gage location had rates ranging from 1.2 to 3.5 feet per hour with a peak stage in 1971 of approximately 48 feet (MSL) and a depth of about 23 feet. The depths of flow above the overbanks during this storm of record range up to 20 feet.

15. In order to locate those sections of the flood plain where early warning and evacuation would be most critical in times of imminent flooding, both existing and potential future high hazard areas were identified. High hazard areas are defined here as areas where the velocity of the floodwaters are such that persons trapped in the area would be knocked off their feet and carried off by the flood. In this study any area with a overbank velocity of four feet per second (fps) or greater is designated as a high hazard area. These areas are shown on Plate E-18. The plate was prepared based on the elevation of the overbank velocity

distribution for a SPF flow for two conditions. First, the boundary of the 4 fps and greater velocity flows was determined and plotted as an iso-velocity line for the existing flood plain. In order to estimate the maximum extent of the high hazard areas in the future due to encroachment of the flood plain it was assumed that no flow would be carried outside of the 100-year flood plain. The water surface profile and overbank velocity distribution were reevaluated for this condition. New outlines showing the location of the 4 fps iso-velocity lines within the overbanks were then plotted. The shaded area between the two iso-velocity lines on Plate E-18 is the area which potentially could be added to the high hazard area due to future encroachments.

## GOOSE CREEK WATERSHED

16. This sub-section describes hydraulic studies for Goose Creek in West Goshen Township and West Chester and includes a description of the flooding problem, discussion on the 1971 storm conditions, the flow and stage relationships at specific locations, and development of the 50-year existing and design flow conditions. The 1971 storm was approximately a 50-year frequency event and was the only storm for which high water marks were available. As a result of this and the limited natural channel capacity of Goose Creek, the 50-year flow condition was used for verification of the hydraulic model and analysis. Because of the urban nature of the flooding, the pattern of flooding is presented prior to continuing with the discussion of the analysis.

### DESCRIPTION OF FLOOD PROBLEM

17. Storm runoff through the Borough of West Chester follows a relatively complex pattern due to the existence of many man-made flood-retarding structures. In order to evaluate existing flooding problems, these patterns and flow characteristics were analyzed in detail. As flow begins to increase to 150-200 cfs in Goose Creek in the vicinity of Cedar and South Franklin Streets, the culvert passing underneath the street and Hoopes Factory cannot handle total flow and overbank flow begins (see Plate F-19). Flow runs south on South Franklin Street to Barnard Street and then westerly toward Goose Creek near the railroad underpass. Runoff from west of the railroad embankment also converges on the Barnard underpass with the combined flow being carried in Goose Creek toward Union Street. The Union Street railroad culvert is undersized and causes ponding at this location even during relatively low flows. If incoming flows to this location are greater than 300-400 cfs, then ponding begins to spill through an alley out to South Franklin and then down toward Union Street. Ponding will then occur in the Union Street area. During major storms this ponding builds up to a point where flow runs southerly on Adams Street to the railroad spur line and turns

easterly toward Bolmar Street. Some additional ponding occurs in the vicinity of Bolmar Street between Union and Nields Streets because storm drains are inadequate to pass local runoff. Natural drainage paths have been altered and backed up flows must pass through and around the Wyeth Laboratories and in a southerly direction on Bolmar Street to Nields Street, then southwesterly toward the ponding area north of the railroad embankment. This ponding area also receives substantial runoff from the West Goshen Township via East Branch Goose Creek. Due to the small 12 sq. ft. culvert opening and backed up flow conditions on the south side of the railroad embankment, ponding occurs quite often. During major storms this ponding rises to about elevation 400-401 and then pass over the railroad embankment. A large culvert at this location would shorten the duration of higher levels of ponding but will do very little toward reducing the peak stages. Channelization, in addition to a large new culvert, must also be carried out to permanently reduce the ponding.

18. Flooding problems on the southern side of the railroad embankment along Goose Creek are similar to those mentioned above. For those flows that do pass the Union Street Railroad Culvert and the natural runoff from the southwestern side of the watershed, there is insufficient channel and structure capacity to allow passage of more than 200-300 cfs without overbank flow. The approximate area extent of the September 1971 flooding is shown on Plate F-19. Backwater effects from Goose Creek in the vicinity of East Goose Creek can be seen up to approximately Nields Street. Channelization of Goose Creek below Linden Street will relieve this backwater effect but will not substantially reduce the overbank conditions at Lacy Street and Nields Street.

## 1971 STORM SIMULATION

19. The 1971 storm conditions were analyzed; the approximate flooding outline and peak water surface profile along Goose Creek are shown on Plate F-19. The areas that incur major damages are located near the railroad embankment in the southwestern portion of the approximately 2 sq. mi. basin.

20. During a field reconnaissance of the flooding area, field notes and measurements were made and utilized with 1" = 400' strip topography to assist in determining flow patterns and relationships. A few high-water marks available from the 1971 storm were used along with hydraulic computations on existing floodways and structures, and hydrologic computations in order to route flows through the flooding area and evaluate storage effects.

## STAGE-DISCHARGE INFORMATION

21. Stage-discharge relationships were developed at four locations on Goose Creek—Cedar and Franklin Streets, Union Street railroad culvert, Lacy Street, and Linden Street. Hydraulic computations were used with minor adjustments being made to reflect the 1971 storm highwater conditions and flow relationships. These stage-flow curves were used with flow-frequency and stage-damage curves at each of these locations to evaluate the average annual damages.

## FLOOD PLAIN CHARACTERISTICS

22. The approximate 50-year flow conditions are shown on Plate F-20. A substantial amount of flow is being naturally diverted down South Franklin Street toward Nields Street. Additional local runoff problems compound flooding problems in the vicinity of Bolmar Street between Union Street and Nields Street. The storage effect on decreasing the peak flows is rather minimal for major storms as most of the peak flow is being passed over the railroad embankment.

23. The 10, 25, 50 and 100-year flow conditions were also evaluated for Goose Creek. Although there are significant variations in the magnitude of flows for these storms, the areas of inundation are relatively similar. This is primarily due to the inadequate flow areas of existing culverts. Flood stages are, therefore, often controlled by street elevations over which excess floodwaters must flow in order to continue downstream. The following table presents the water surface elevations (WSE) for the 10, 25, 50, and 100-year floods at the four index stations. Note the small difference in elevations even between the 10-year and 100-year floods.

| Location | Index Stations | Frequency | | | |
|---|---|---|---|---|---|
| | | 100-Year | 50-Year | 25-Year | 10-Year |
| Cedar & Franklin Sts. | 1 | 416.1 | 415.7 | 415.4 | 414.9 |
| Union St. Railroad Culvert | 2 | 416.0 | 415.2 | 413.2 | 412.4 |
| Lacy Street | 3 | 406.0 | 405.9 | 405.8 | 405.3 |
| Linden Street | 4 | 401.2 | 400.7 | 400.2 | 399.7 |

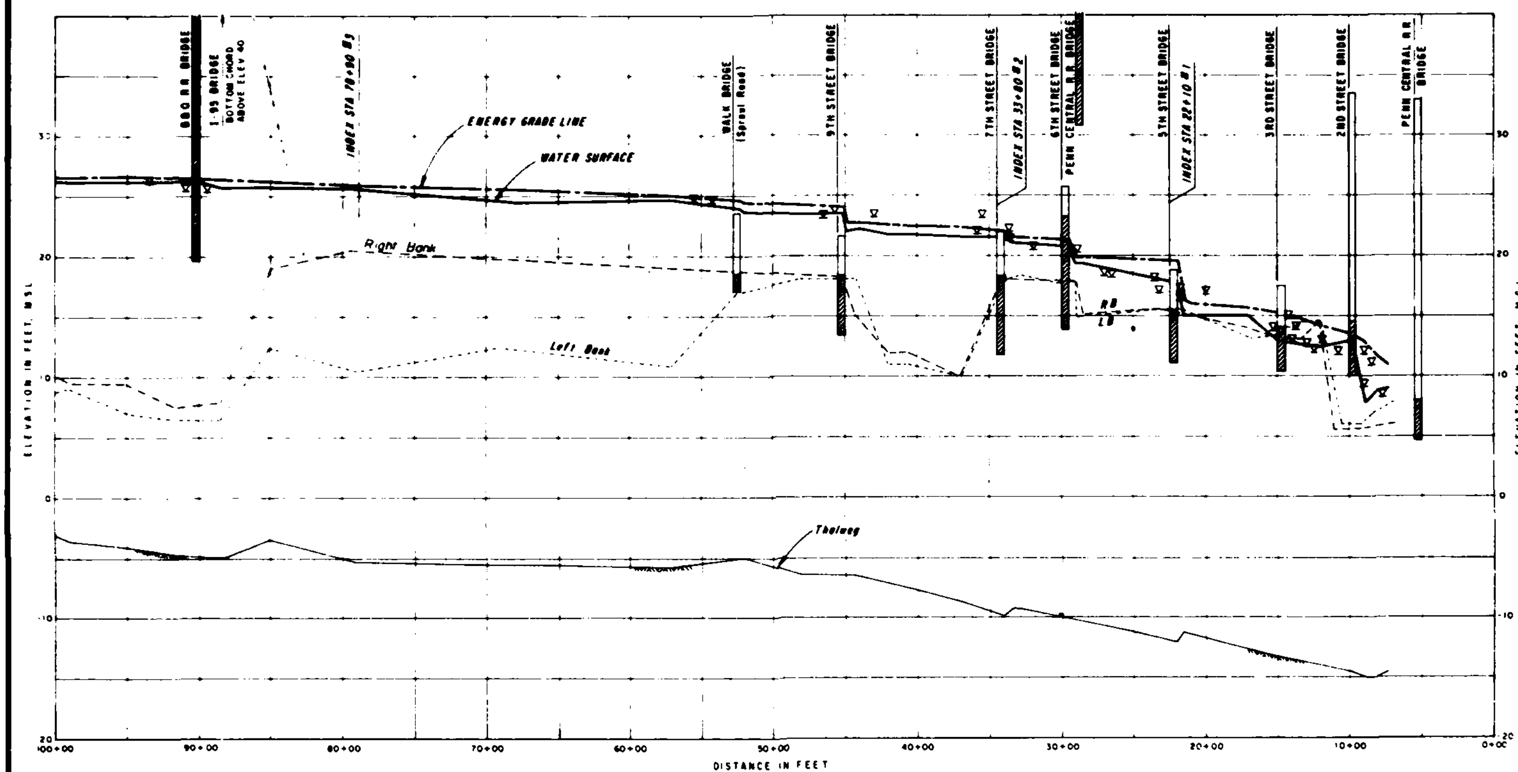
## COMPARISON WITH OTHER STUDIES

24. Following the completion of hydraulic studies available Federal

Flood Insurance Administration (FIA) studies in the major damage reaches were obtained and the results compared with the results of this study. The Chester and Upland FIA studies showed somewhat lower stages (1-1/2 to 2-feet) for the 10 and 50 year floods for Eyre Park downstream. This is probably due to the lower discharges predicted by the FIA study (See Appendix 1, Section E). All other comparisons showed differences of less than 1-foot.

25. Work by Michael Baker Engineers (MBE), Inc. in the Borough of Brookhaven for the Federal Insurance Administration was also evaluated. A significant difference was noted between the rating curve (stage vs. flow) developed by Baker and that computed in this study. The curves computed for the Chester Creek Study compare favorable with the USGS Gage 4770 curve near Dutton Mill Road. Significant differences were noted between Baker's stage-flow information and the gage's rating curve for the more frequent events. For the 10-year event, MBE stages were 3-feet lower.

26. The HUD Flood Insurance Studies for West Chester and West Goshen by Betz Environmental Engineers were evaluated to determine if any large differences in water surface elevations existed between their flow profiles and the stage-frequency-flow functions developed in this study. Although small differences in stages were detected throughout the Goose Creek Study area, the only major difference in stages occurred at Union Street. At the location Betz's stage was approximately 1-1/2 feet below the calculated stage for a 50-year flow. Hydraulic analysis at this particular location is quite difficult since the flow leaves the channel and travels overland on the north side of the railroad during flood flows. Considering this fact, the differences in water surface profiles were considered within reasonable accuracy.




**LEGEND**

- ⊻ HIGH WATER MARK - USGS
- TOP OF BRIDGE
- ROADWAY OR RAIL
- MAX LOW CHORD

NOTES:

1. RIGHT AND LEFT BANKS REPRESENT ELEVATIONS AT WHICH DAMAGES WILL BEGIN TO OCCUR.
2. THALWEG IS A PROFILE LINE JOINING THE LOWEST POINTS ALONG A STREAM BED WHICH GENERALLY MARKS THE SLOPE OF THE STREAM THROUGHOUT ITS COURSE.

CHESTER CREEK BASIN, PENNSYLVANIA

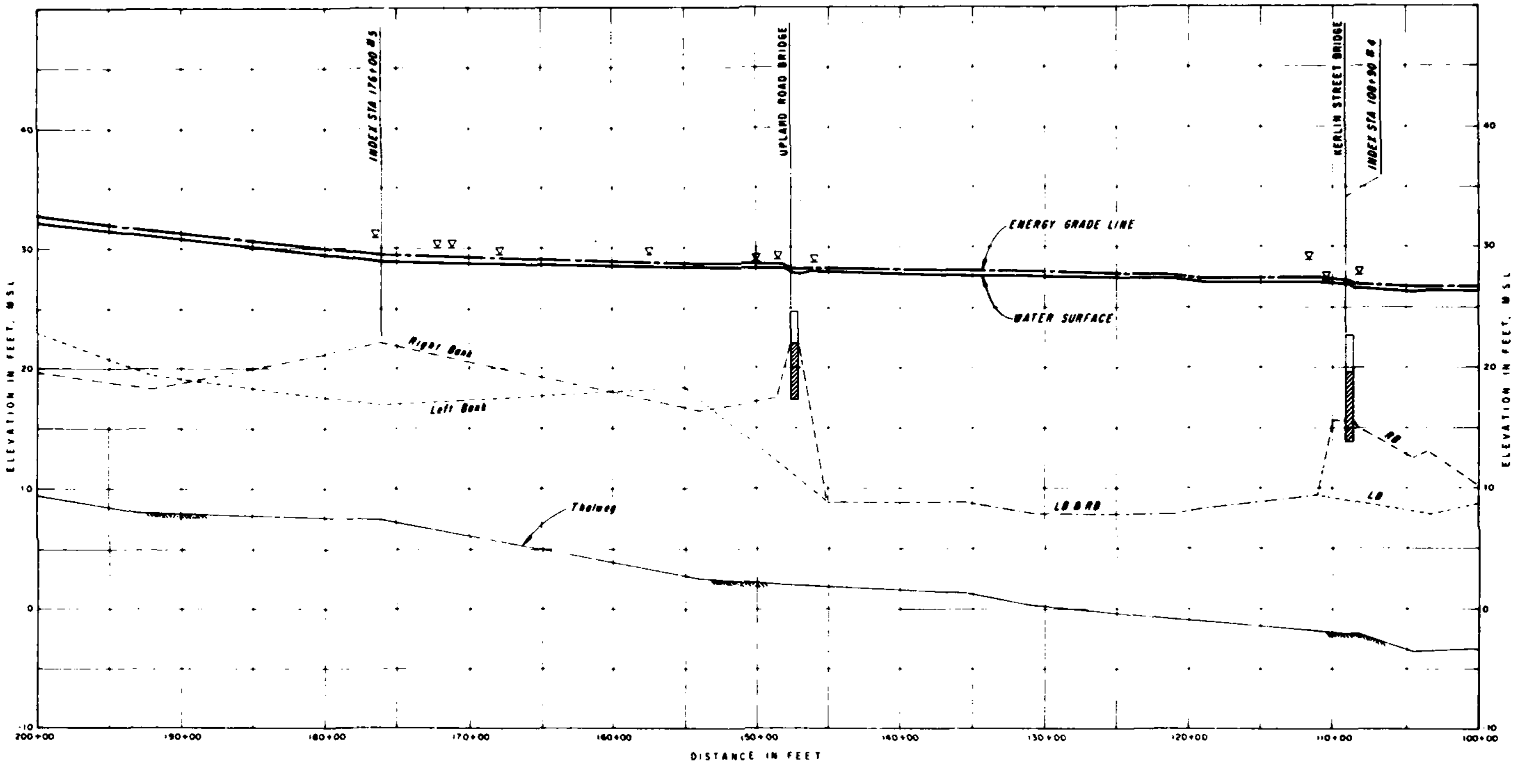
**CHESTER CREEK PROFILE**

**PEAK FLOW CONDITION - SEPT. 1971 STORM**

**STA. 0+00 TO STA. 100+00**

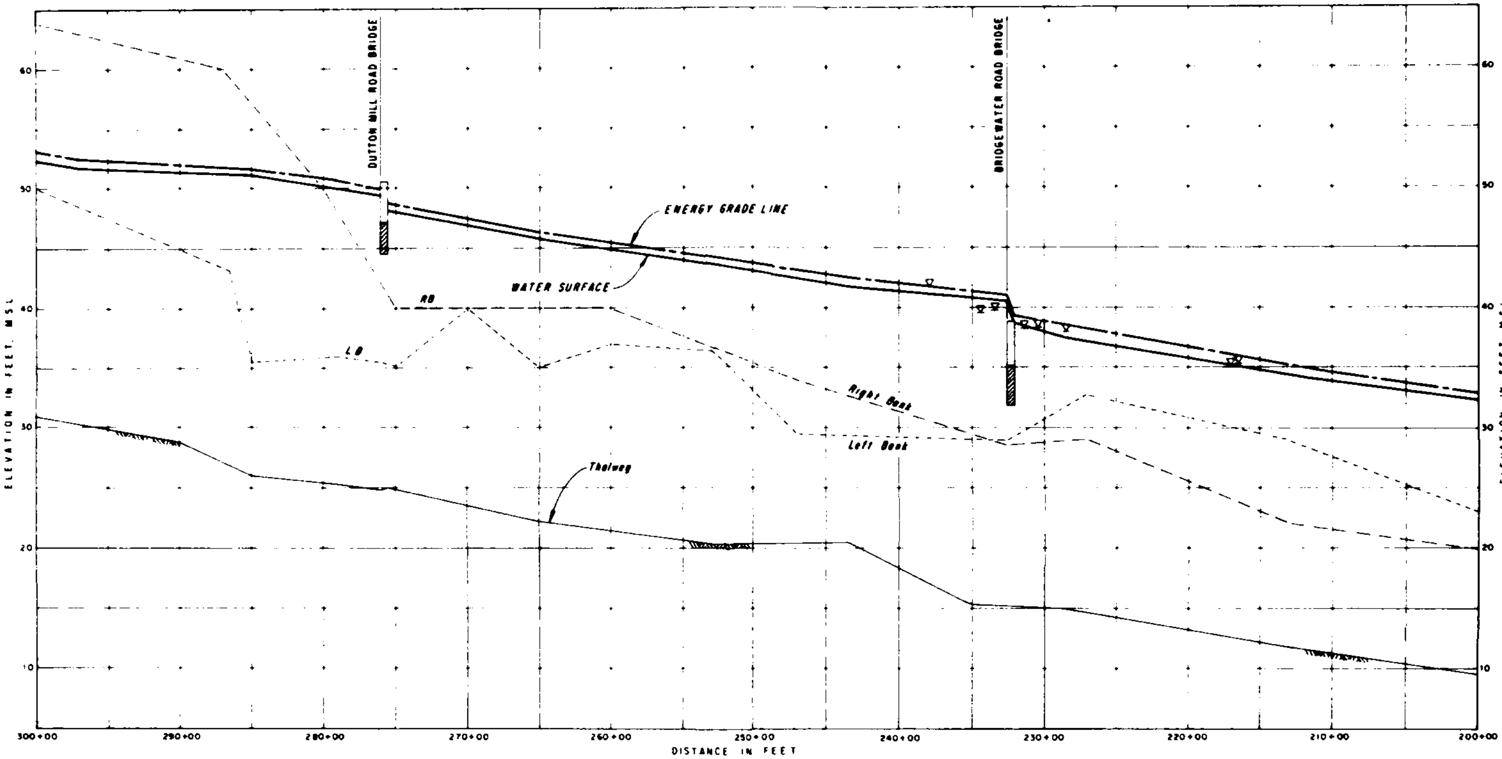
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978



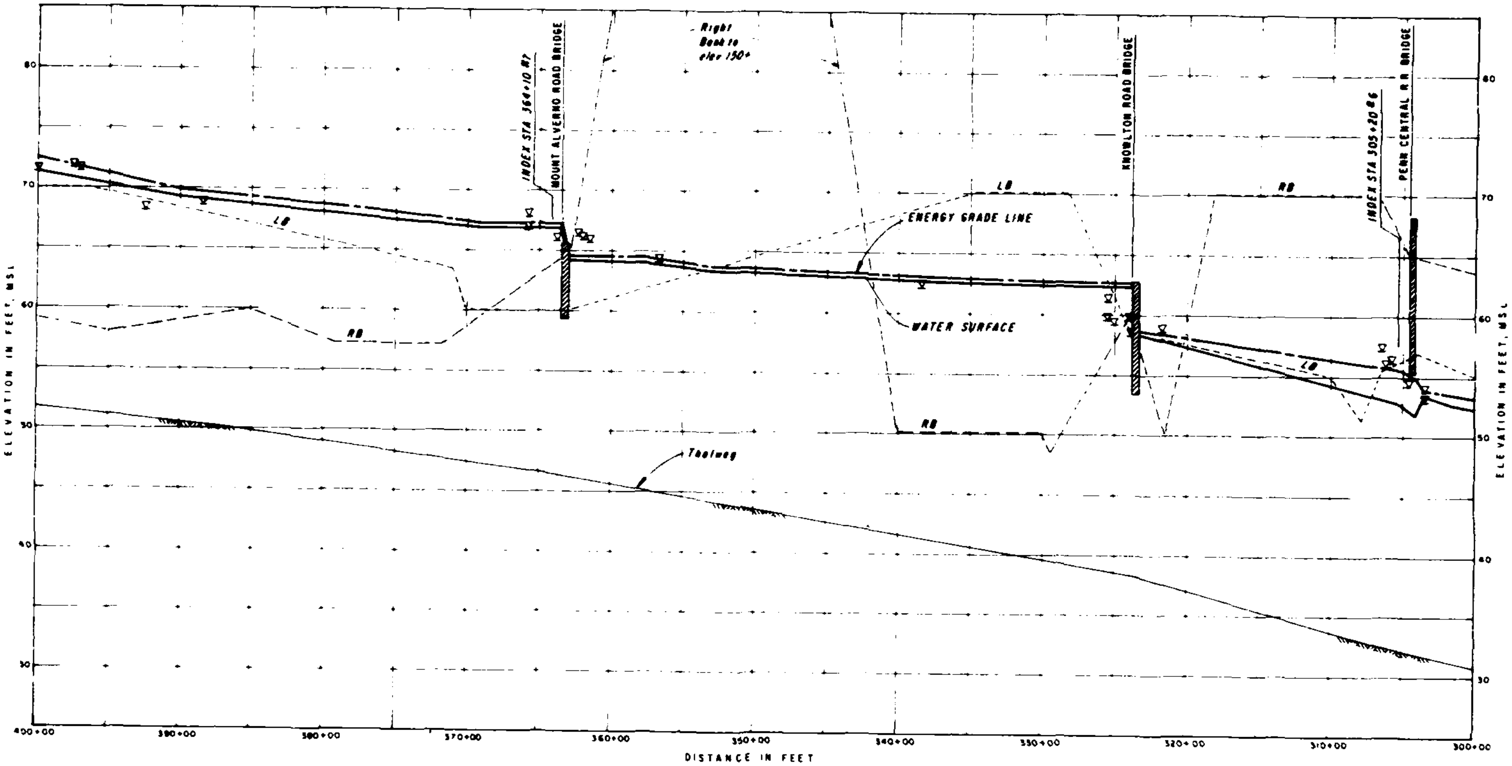

CHESTER CREEK BASIN, PENNSYLVANIA
CHESTER CREEK PROFILE
PEAK FLOW CONDITION-SEPT. 1971 STORM
STA 100+00 TO STA 200+00
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE F-2



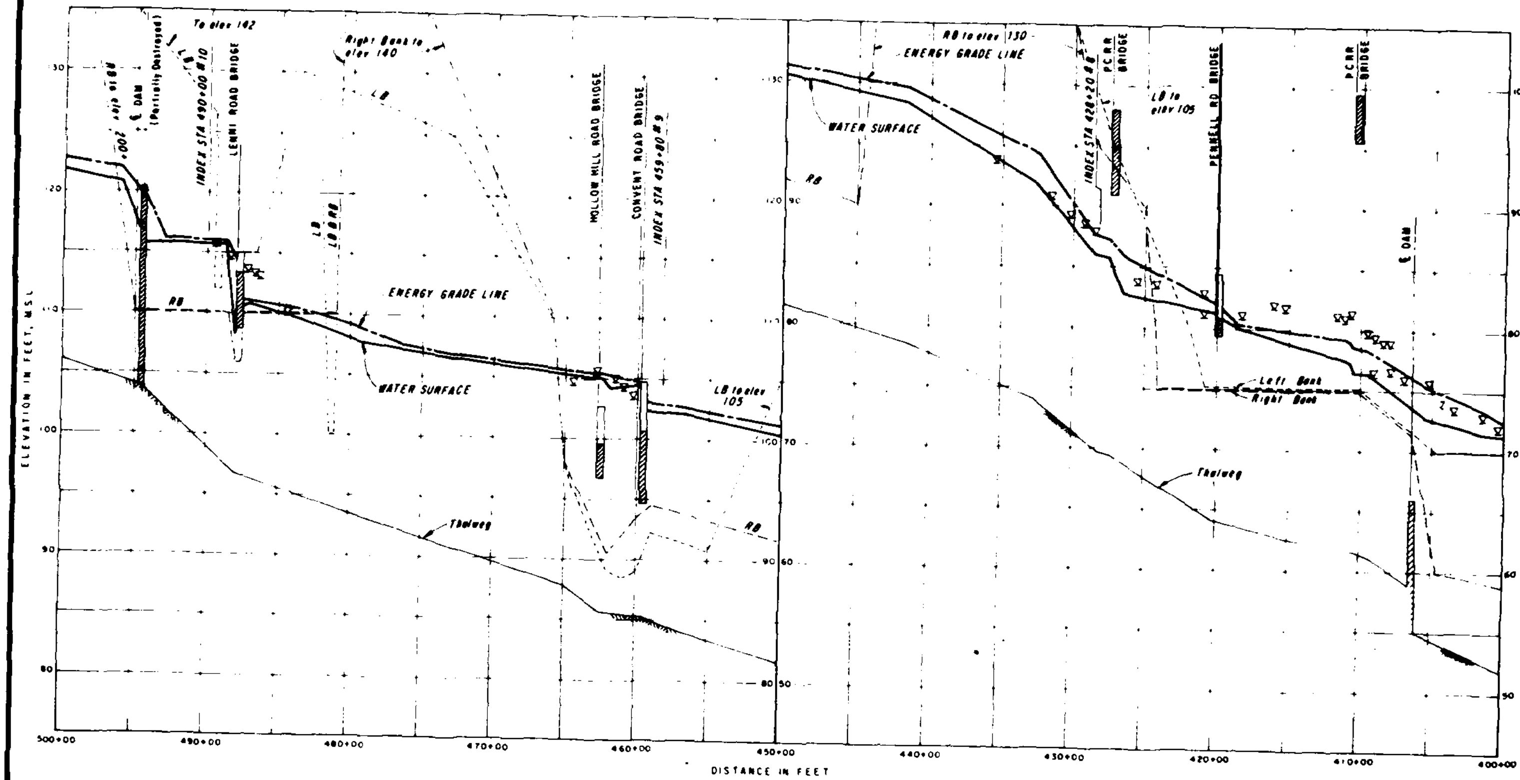

CHESTER CREEK BASIN, PENNSYLVANIA
CHESTER CREEK PROFILE
PEAK FLOW CONDITION - SEPT. 1971 STORM
STA 200+00 TO STA 300+00
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE F-3



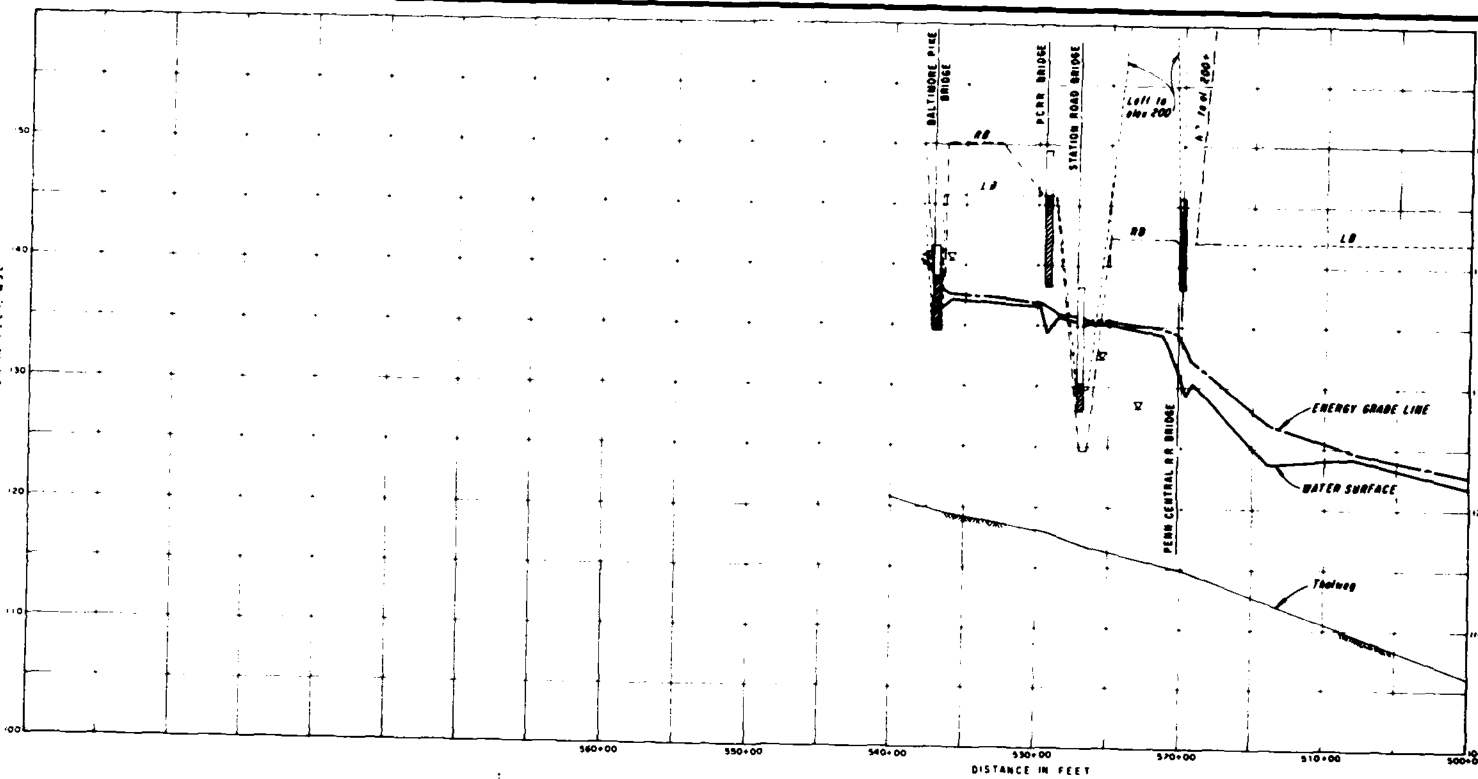

CHESTER CREEK BASIN, PENNSYLVANIA
CHESTER CREEK PROFILE
PEAK FLOW CONDITION SEPT. 1971 STORM
STA. 300+00 TO STA. 400+00
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE F-4



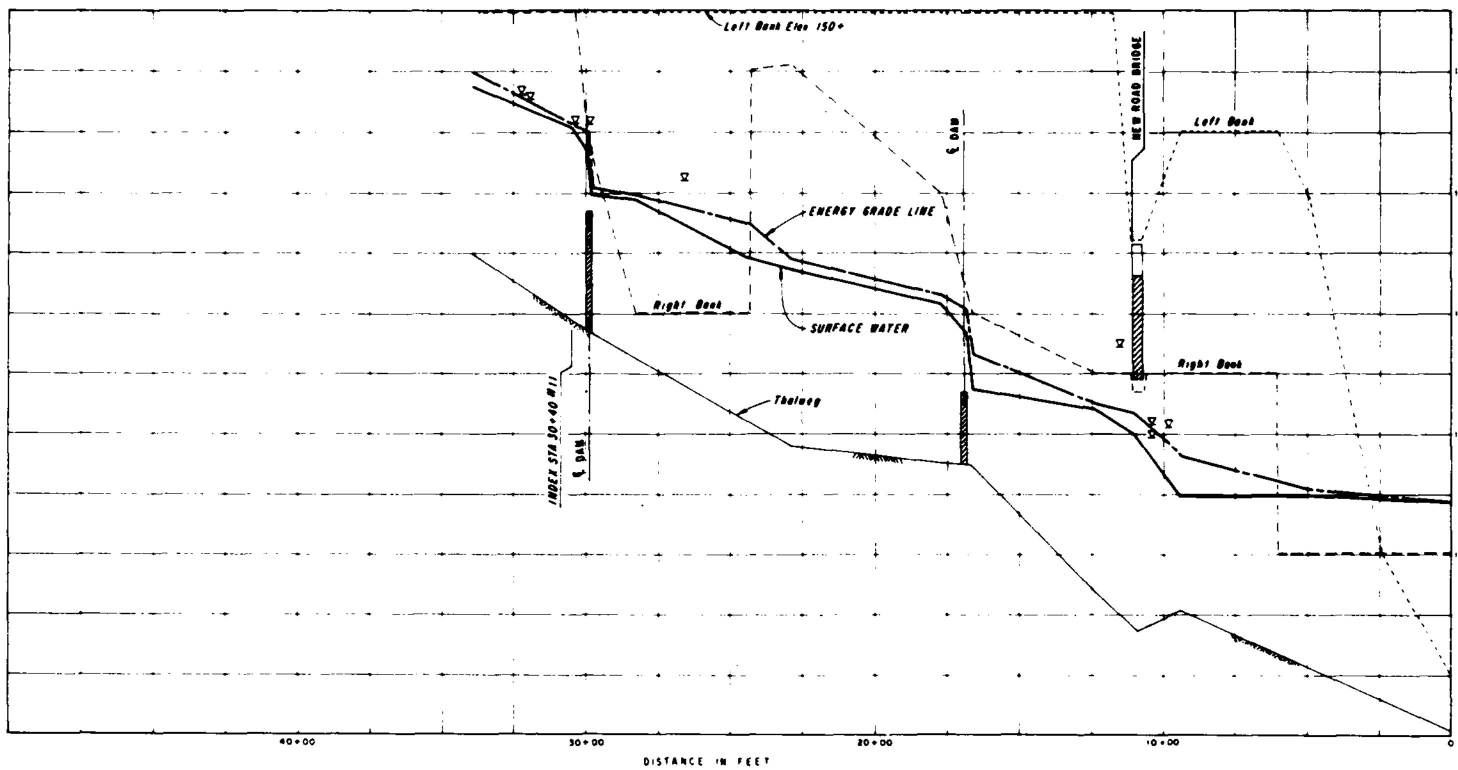

CHESTER CREEK BASIN, PENNSYLVANIA
CHESTER CREEK PROFILE
PEAK FLOW CONDITION-SEPT. 1971 STORM
STA 400+00 TO STA 500+00
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE F-5




CHESTER CREEK BASIN, PENNSYLVANIA
CHESTER CREEK PROFILE
PEAK FLOW CONDITION - SEPT. 1971 STORM
STA 500+00 TO STA 538+00
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE F-6




LEGEND

- HIGH WATER MARK - USGS
- TOP OF BRIDGE
- ROADWAY
- MAX LOW CHORD

NOTES:

1. RIGHT AND LEFT BANKS REPRESENT ELEVATIONS AT WHICH DAMAGES WILL BEGIN TO OCCUR.
2. THALWEG IS A PROFILE LINE JOINING THE LOWEST POINTS ALONG A STREAM BED WHICH GENERALLY MARKS THE SLOPE OF THE STREAM THROUGHOUT ITS COURSE.

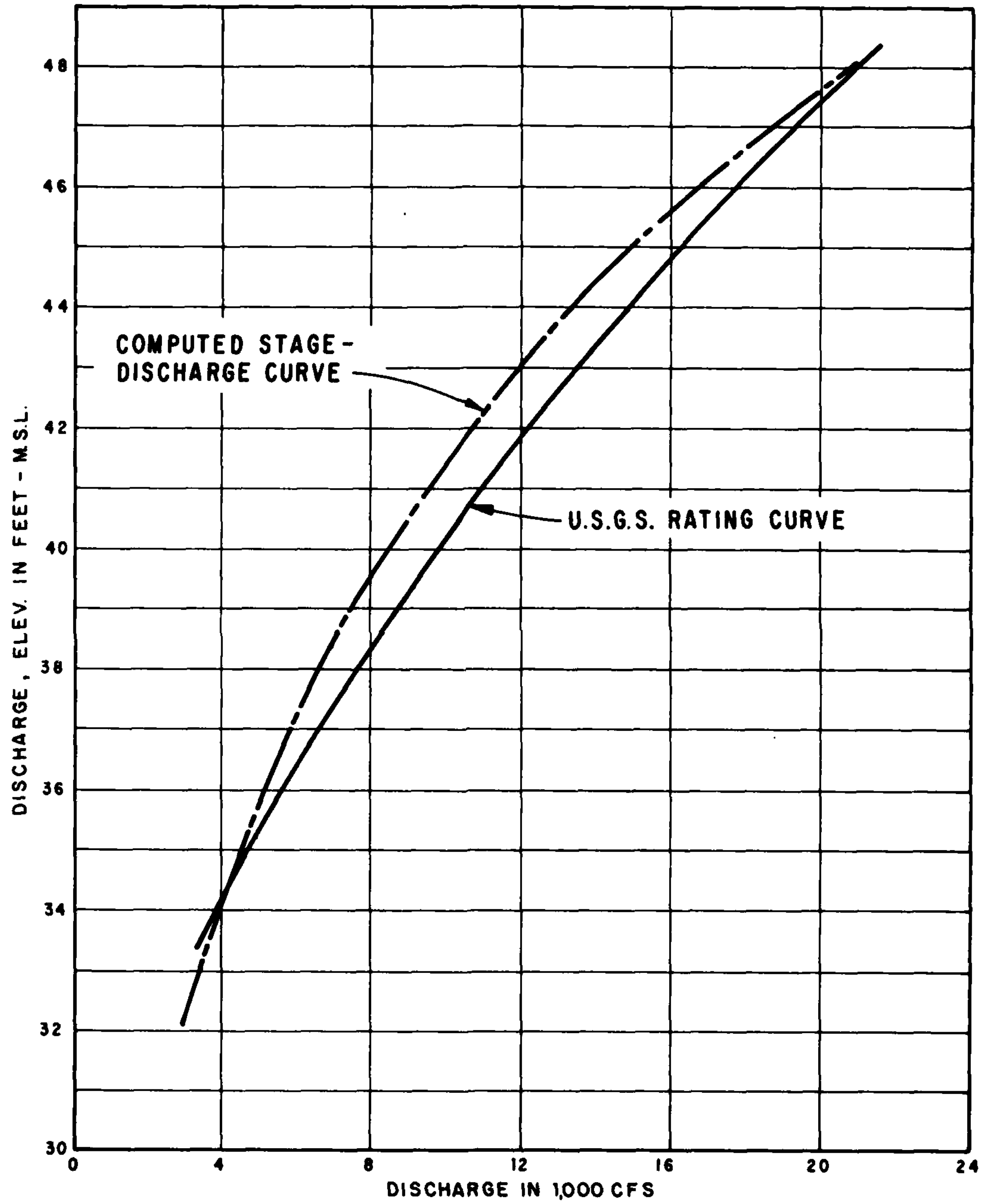
CHESTER CREEK BASIN, PENNSYLVANIA

# CHESTER CREEK PROFILE
# PEAK FLOW CONDITION-SEPT. 1971 STORM
# STA 0+00 TO STA 34+00

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

PLATE F-7




NOTE: Stage-discharge relationship shown for the U.S.G.S. Gage 4770, Dutton Mill Road.

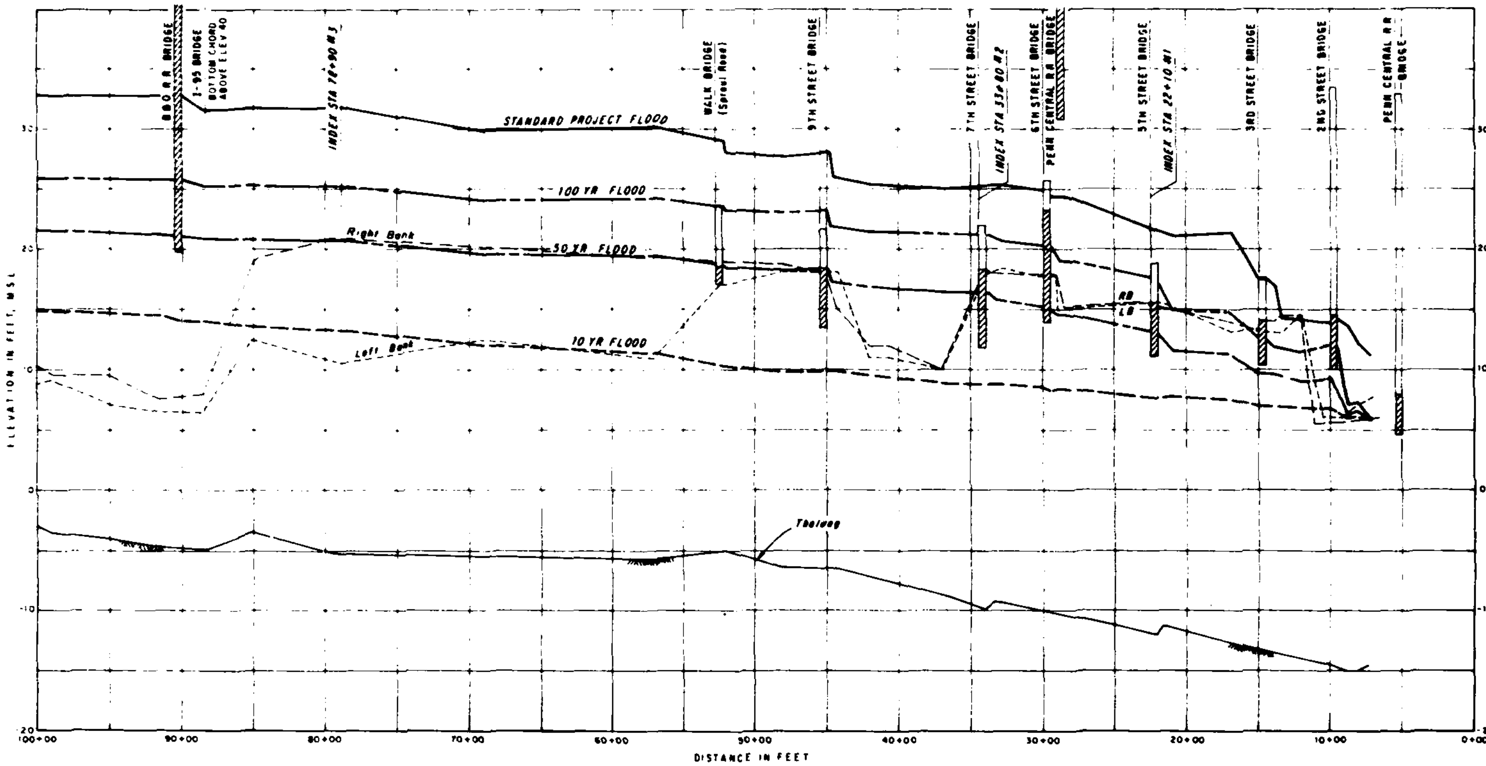
CHESTER CREEK BASIN, PENNSYLVANIA

**STAGE - DISCHARGE**

**U.S.G.S. GAGE**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978




**LEGEND**

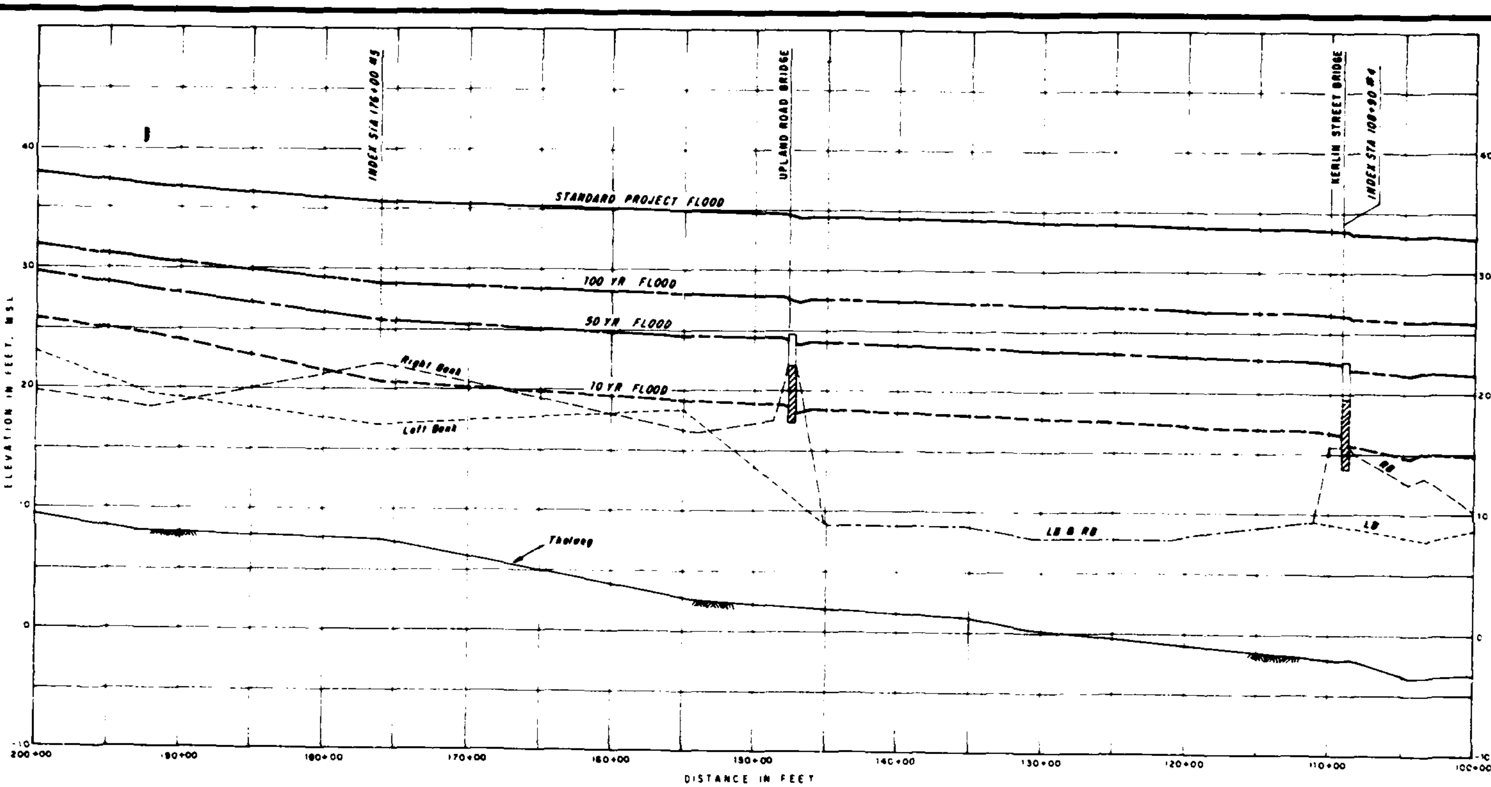
TOP OF BRIDGE
ROADWAY OR RAIL
MAX LOW CHORD

NOTE
1. RIGHT AND LEFT BANKS REPRESENT ELEVATIONS AT WHICH DAMAGES WILL BEGIN TO OCCUR.
2. THALWEG IS A PROFILE LINE JOINING THE LOWEST POINTS ALONG A STREAM BED WHICH GENERALLY MARKS THE SLOPE OF THE STREAM THROUGHOUT ITS COURSE.

CHESTER CREEK BASIN, PENNSYLVANIA

**CHESTER CREEK FLOOD PROFILES**
**STA 0+00 TO STA 100+00**

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

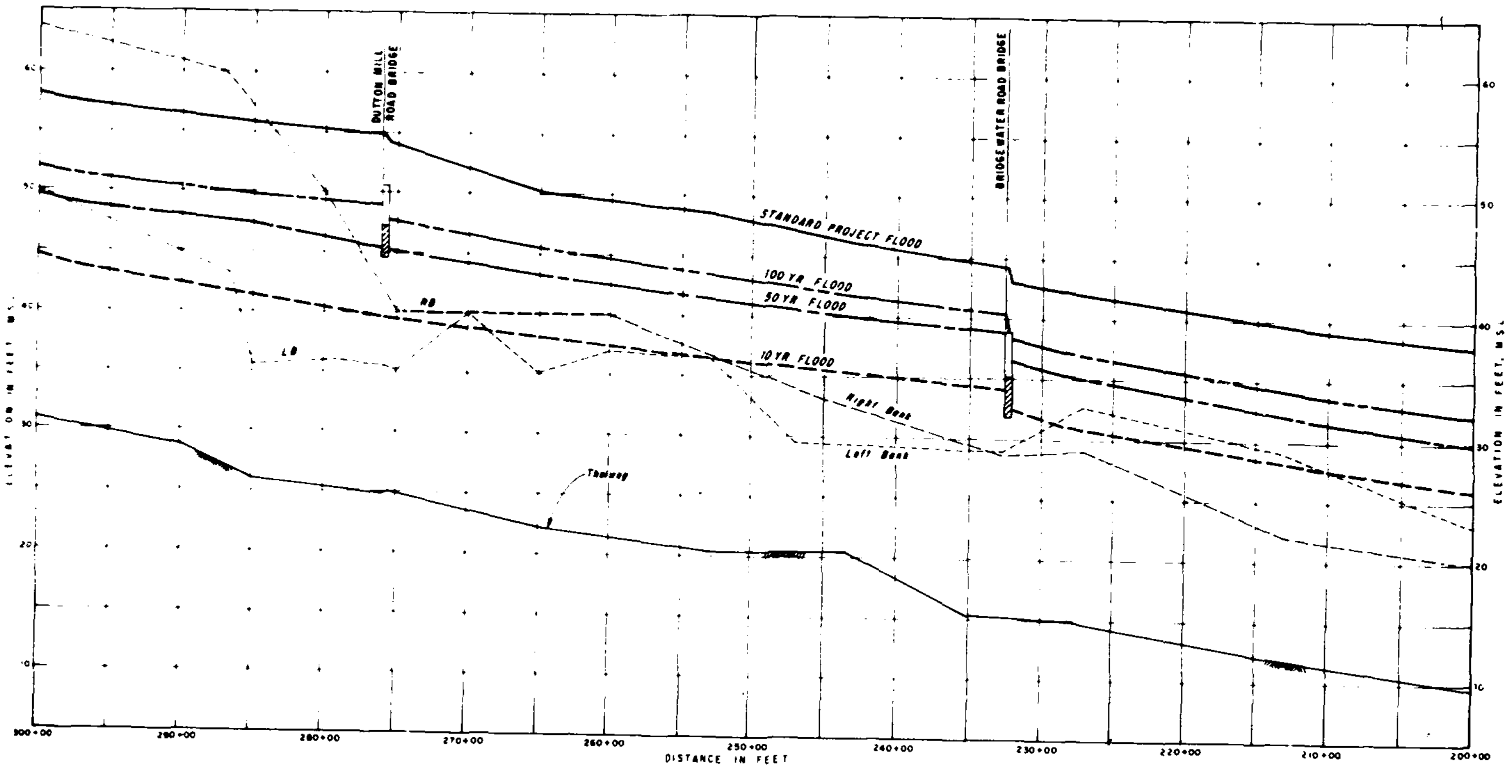



CHESTER CREEK BASIN, PENNSYLVANIA

# CHESTER CREEK FLOOD PROFILES
# STA 100+00 TO STA 200+00

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE F-10

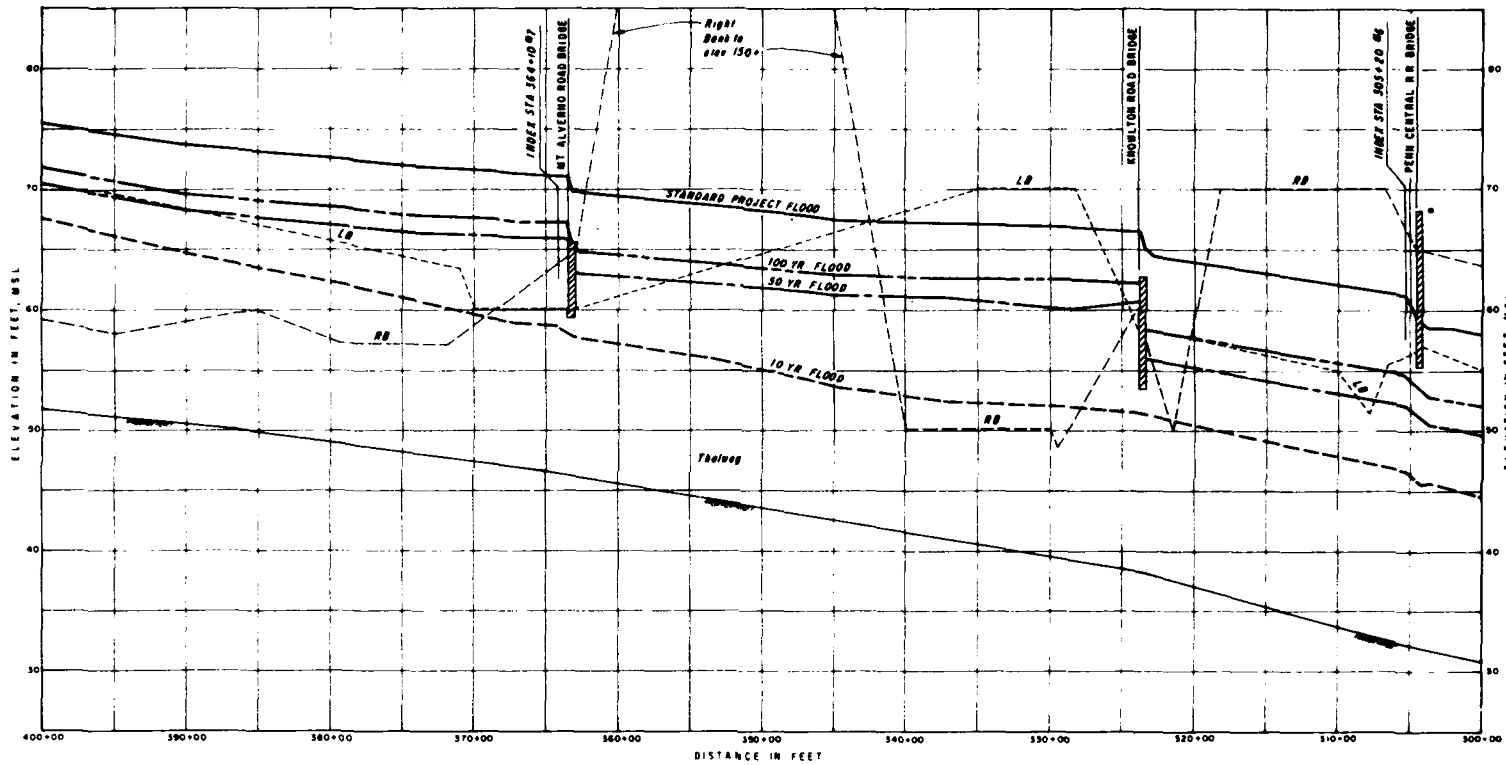



CHESTER CREEK BASIN, PENNSYLVANIA

CHESTER CREEK FLOOD PROFILES
STA 200+00 TO STA 300+00

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE F-11

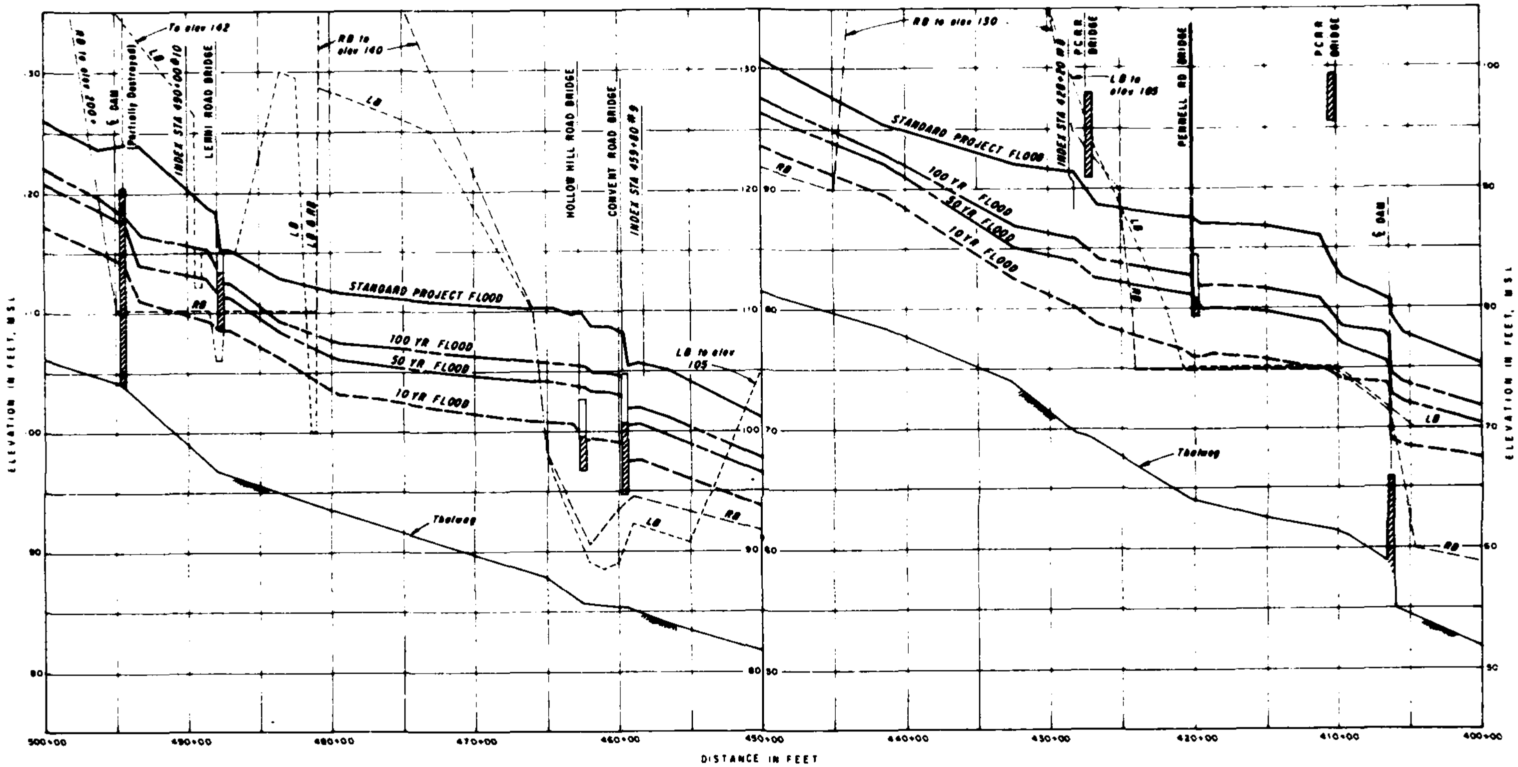



CHESTER CREEK BASIN, PENNSYLVANIA

# CHESTER CREEK FLOOD PROFILES
# STA 300+00 TO STA 400+00

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE F-12

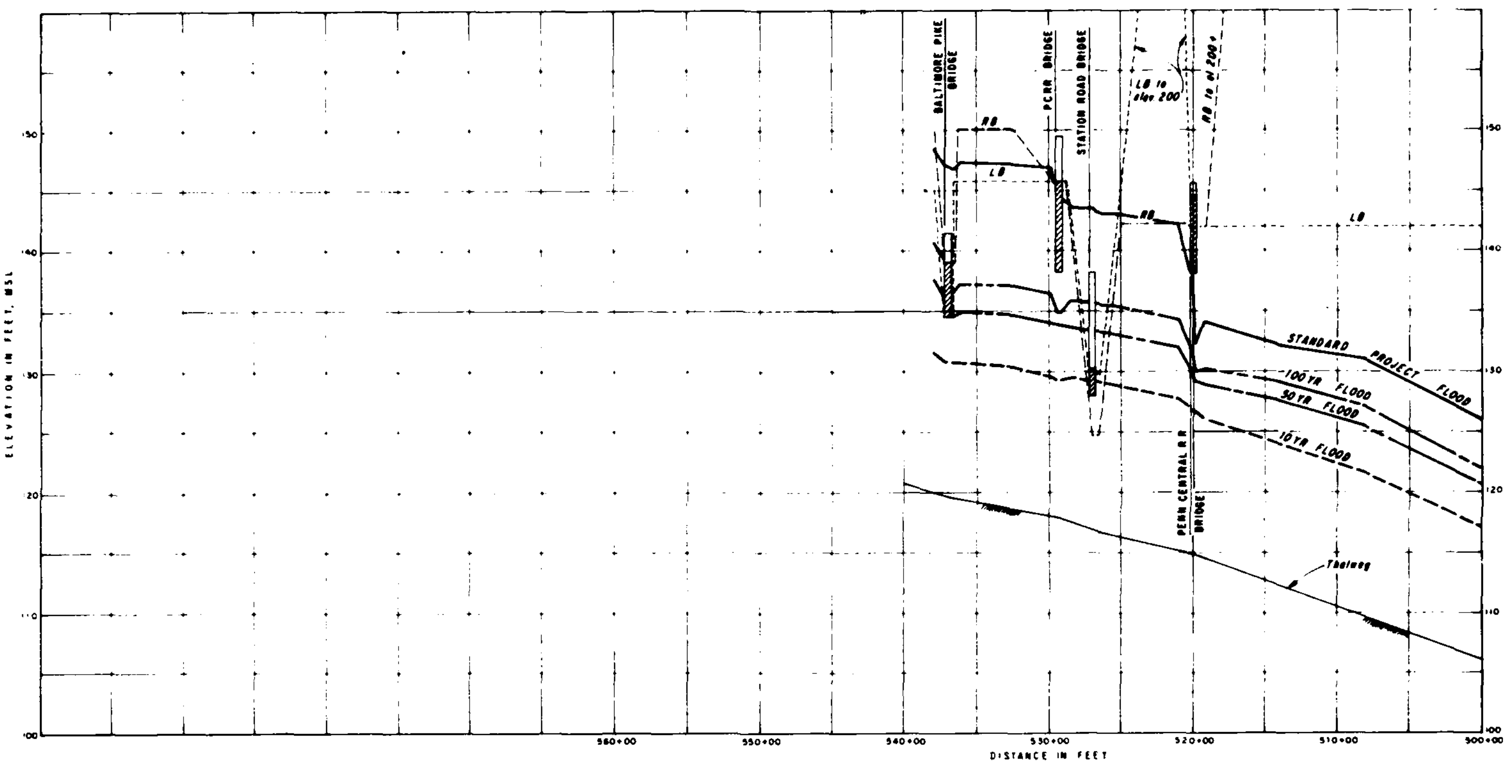



CHESTER CREEK BASIN, PENNSYLVANIA

# CHESTER CREEK FLOOD PROFILES
# STA 400+00 TO STA 500+00

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE F-13

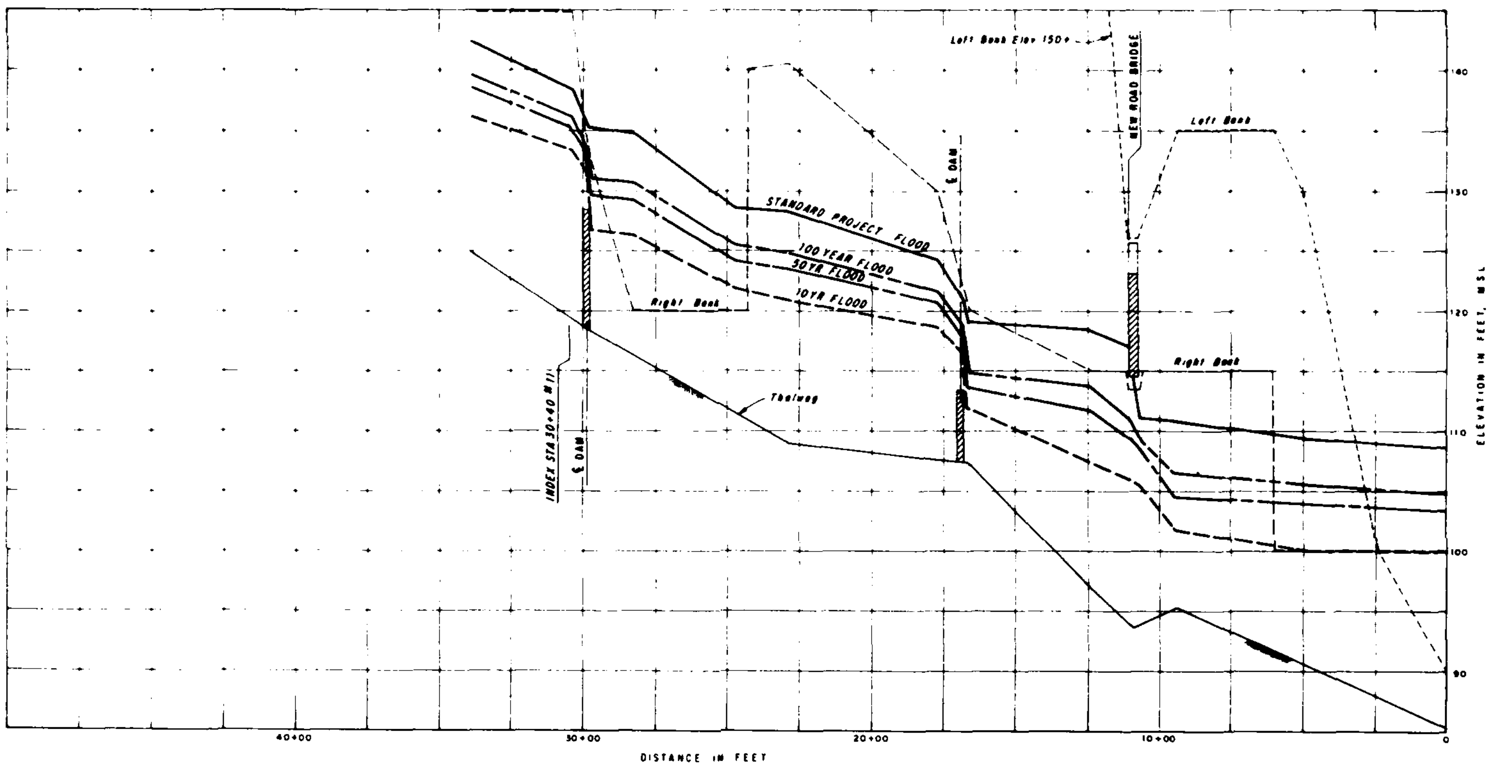



CHESTER CREEK BASIN, PENNSYLVANIA

# CHESTER CREEK FLOOD PROFILES
# STA 500+00 TO STA 538+00

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE F-14




**LEGEND**

- TOP OF BRIDGE
- ROADWAY OR RAIL
- MAX LOW CHORD

NOTE

1. RIGHT AND LEFT BANKS REPRESENT ELEVATION AT WHICH DAMAGES WILL BEGIN TO OCCUR.
2. THALWEG IS A PROFILE LINE JOINING THE LOWEST POINTS ALONG A STREAM BED WHICH GENERALLY MARKS THE SLOPE OF THE STREAM THROUGHOUT ITS COURSE.

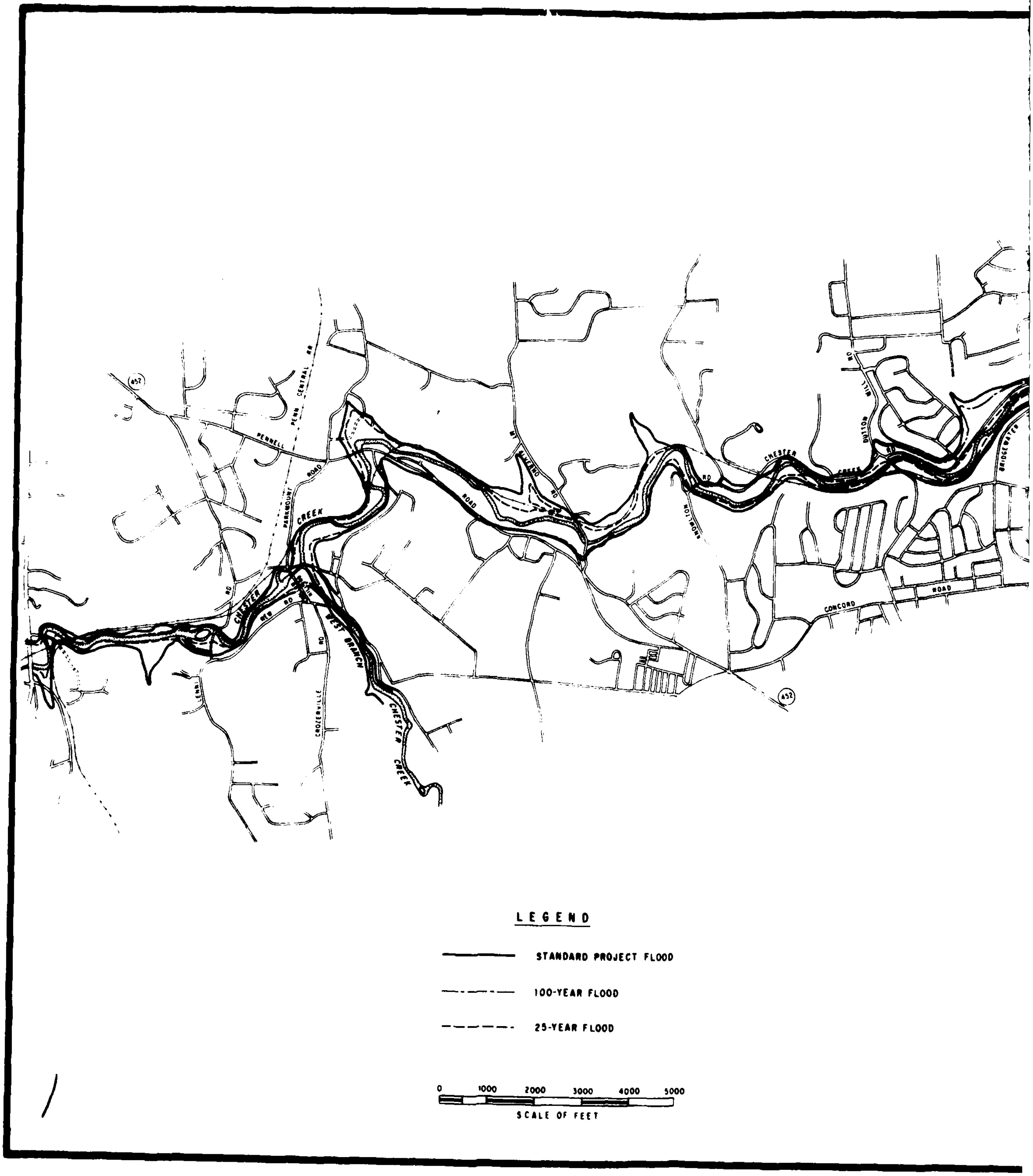
CHESTER CREEK BASIN, PENNSYLVANIA

# WEST BRANCH CHESTER CREEK FLOOD PROFILES

## STA 0+00 TO STA 34+00

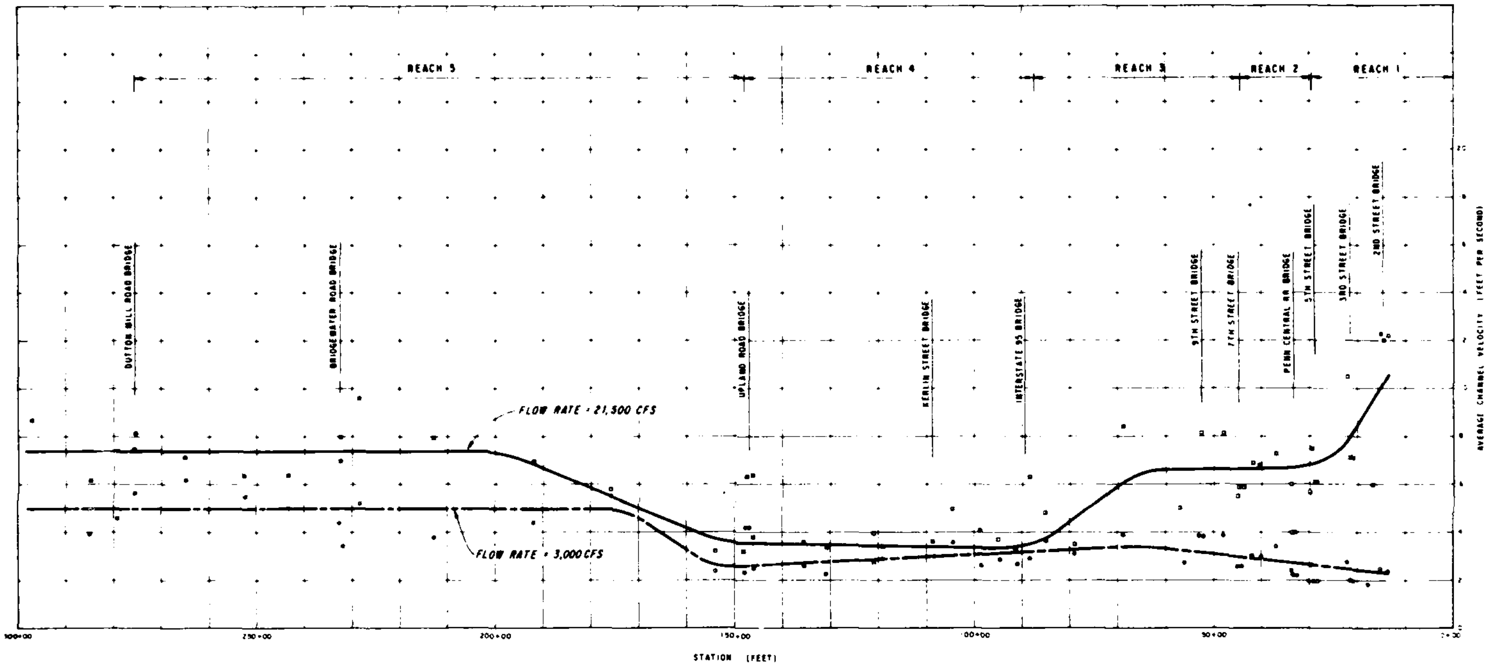
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978



CHESTER CREEK
WEST BRANCH CHESTER CREEK
PENN CENTRAL RR
PENNELL ROAD
PARKMOUNT ROAD
CROZERVILLE
LENNI
CONCORD ROAD
BRIDGEWATER
452
LEGEND
STANDARD PROJECT FLOOD
100-YEAR FLOOD
25-YEAR FLOOD
0 1000 2000 3000 4000 5000
SCALE OF FEET

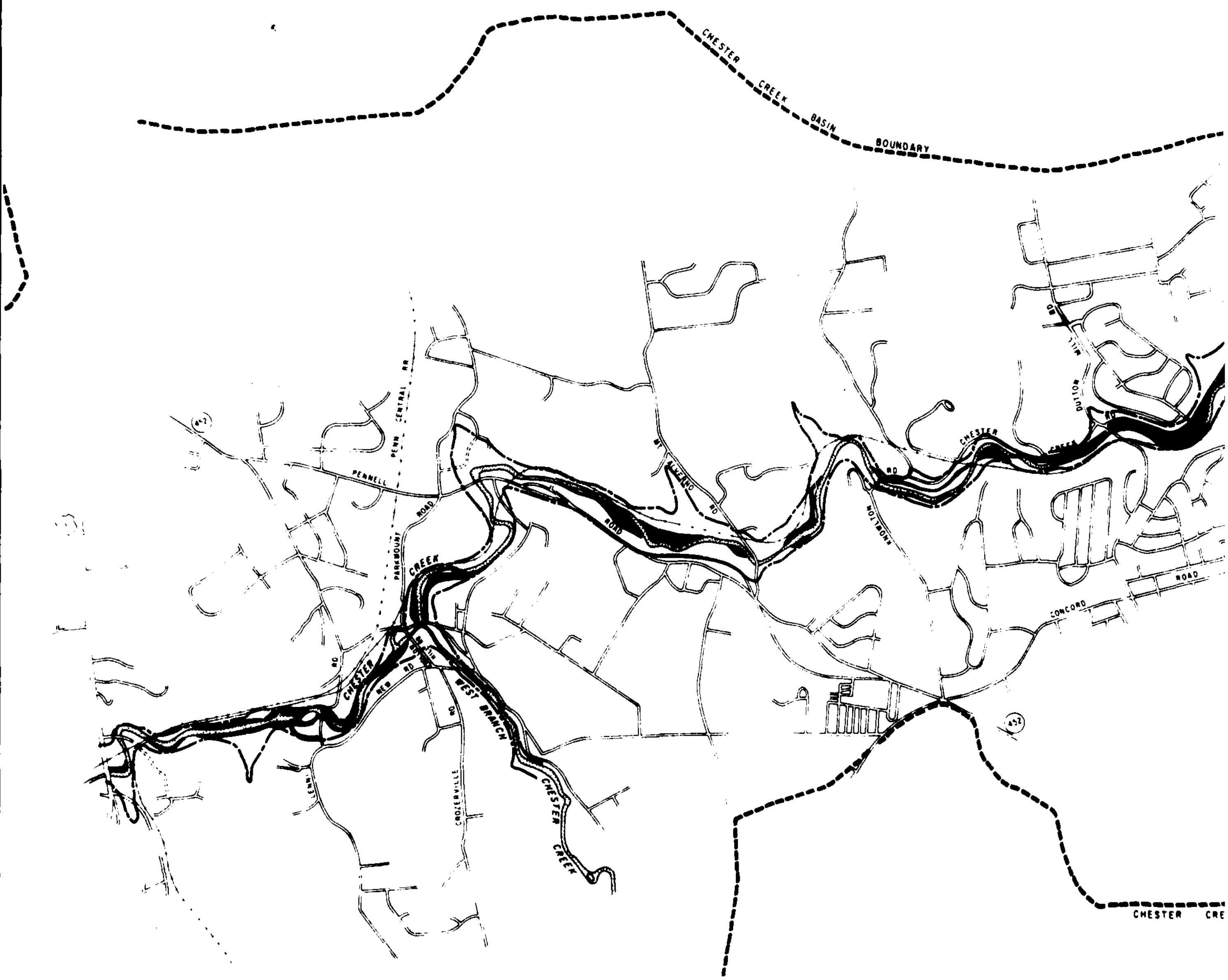

CHESTER CREEK BASIN, PENNSYLVANIA
FLOOD PLAIN LIMITS
25-YEAR, 100 YEAR & STANDARD PROJECT FLOOD
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978




NOTES:
1. ●. FLOW RATE EQUALS 21,500 CFS (APPROXIMATELY A 100-YEAR FREQUENCY)
2. ▫. FLOW RATE EQUALS 3,000 CFS (APPROXIMATELY A 2-YEAR FREQUENCY)
3. VELOCITY CURVES DO NOT REFLECT LOCALIZED VELOCITY CHANGES JUST UPSTREAM AND DOWNSTREAM OF BRIDGES.
4. VELOCITIES ARE BASED ON A TAILWATER ELEVATION OF 6.0 FEET AT STATION 7+30.

CHESTER CREEK BASIN, PENNSYLVANIA
## CHESTER CREEK VELOCITY CHANGES
## DUTTON MILL ROAD TO DELAWARE RIVER
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE F-17



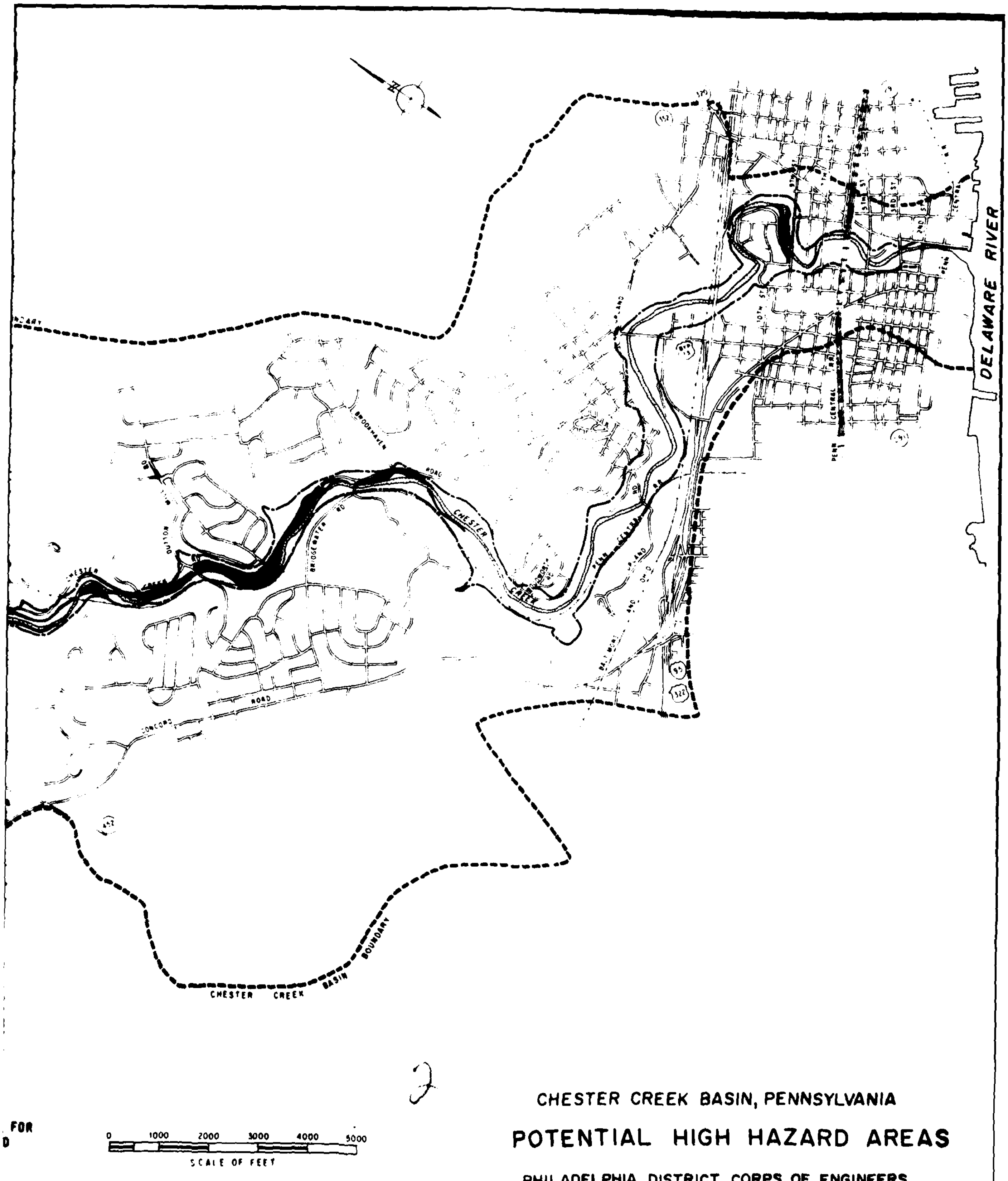

LEGEND

POTENTIAL HIGH HAZARD AREAS

100-YEAR FLOOD PLAIN LIMITS

NOTES: HIGH HAZARD AREAS ARE THOSE FLOOD FLOW AREAS FOR WHICH VELOCITIES ARE GREATER THAN OR EQUAL TO 4 FEET PER SECOND.

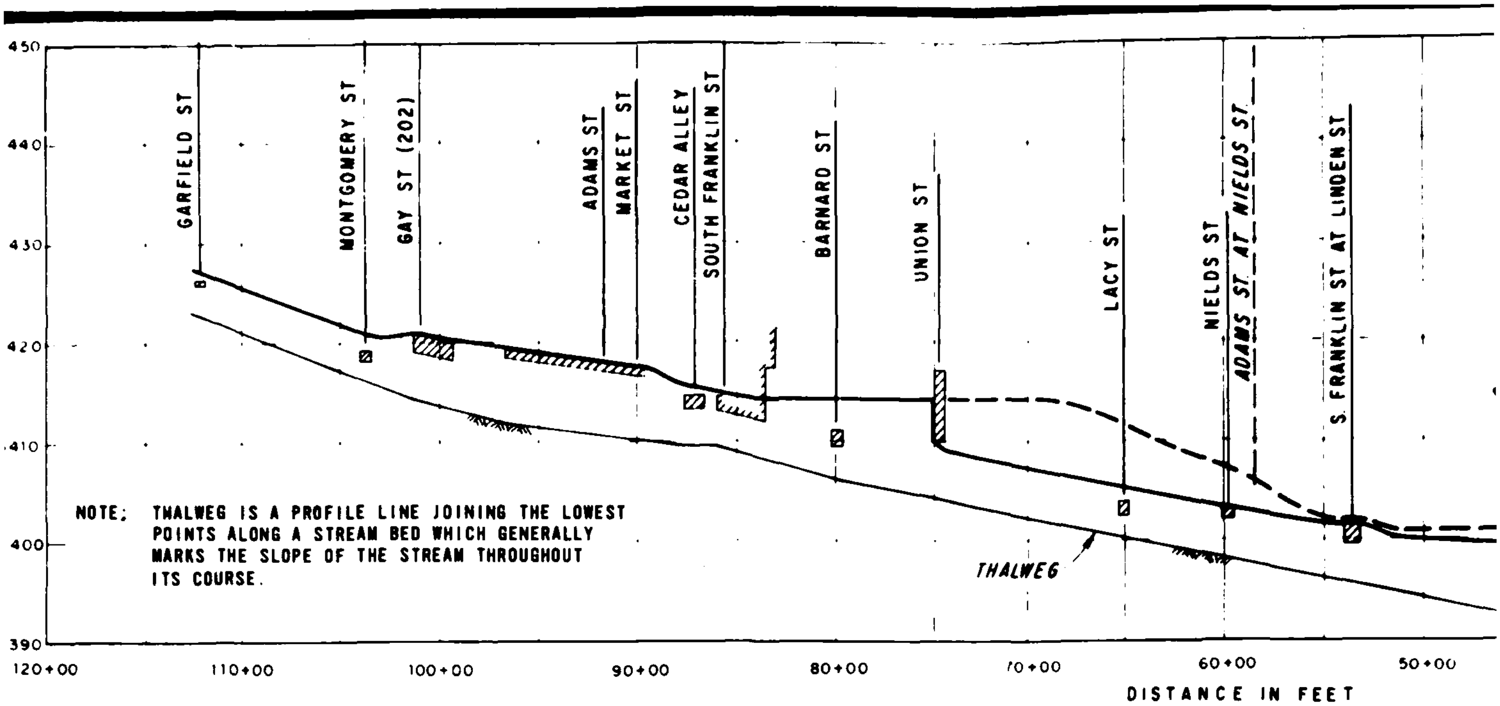
0 1000 2000 3000
SCALE OF FEET



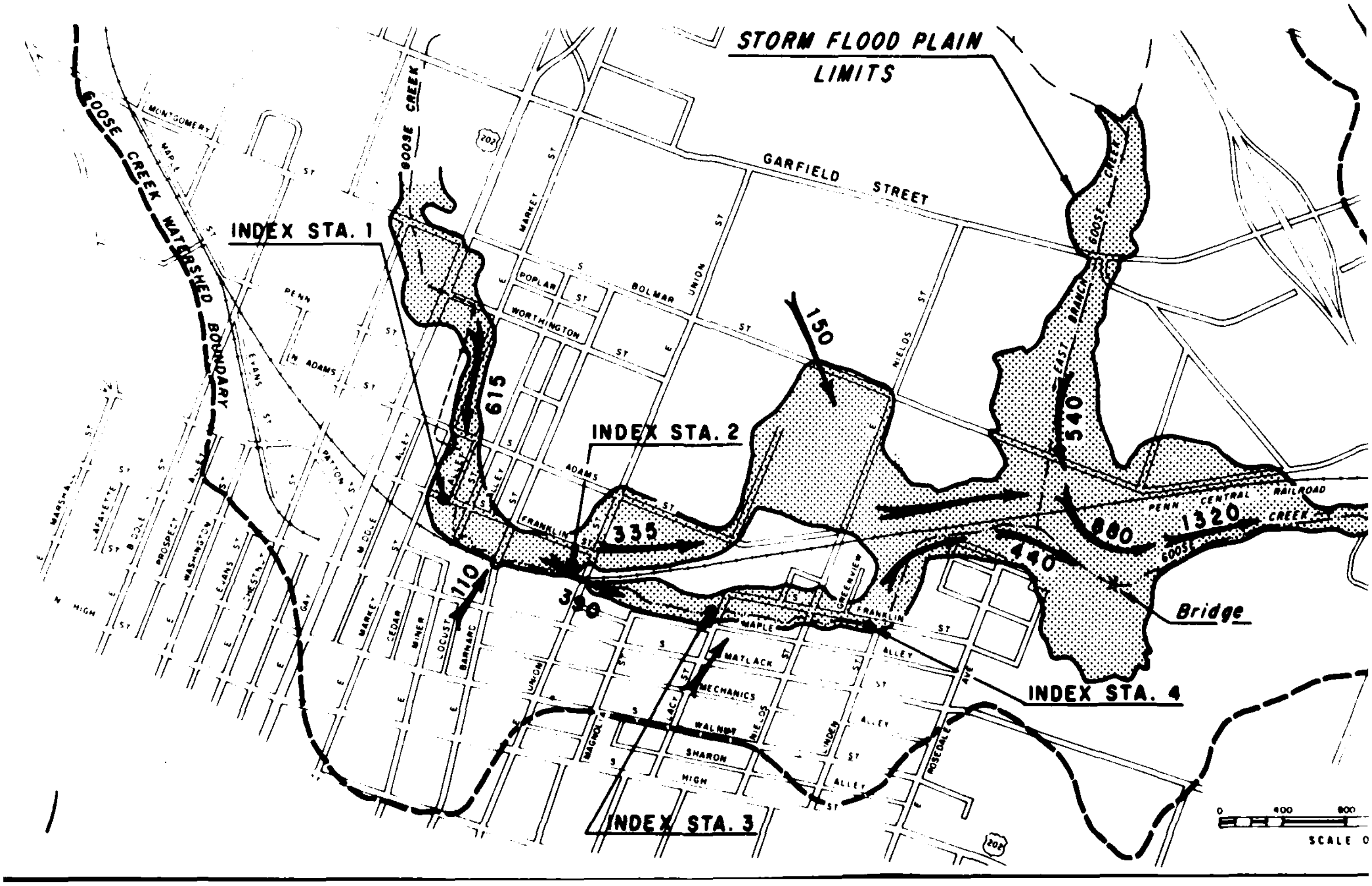

CHESTER CREEK BASIN, PENNSYLVANIA

**POTENTIAL HIGH HAZARD AREAS**

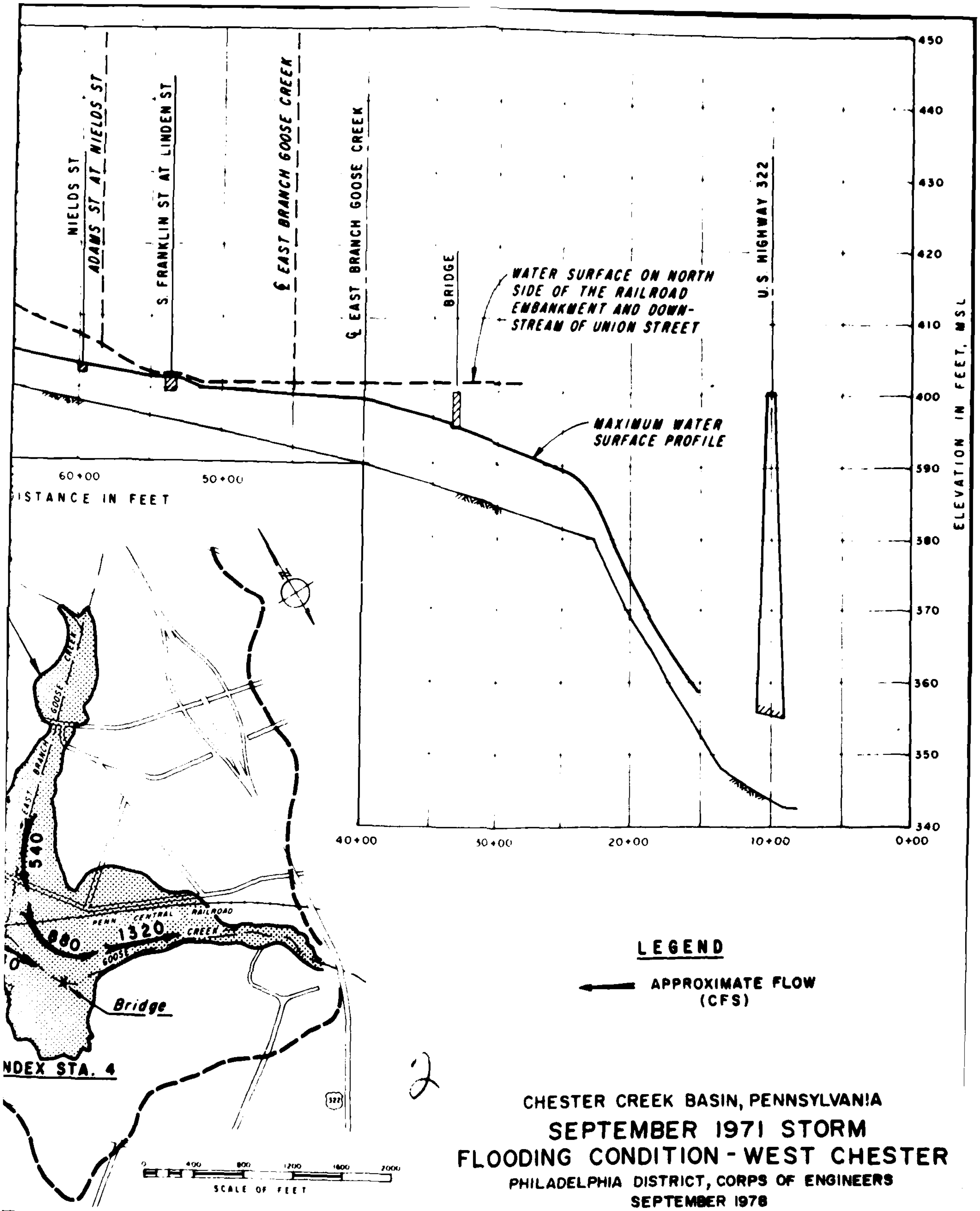
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978



450
440
430
420
410
400
390
GARFIELD ST
MONTGOMERY ST
GAY ST (202)
ADAMS ST
MARKET ST
CEDAR ALLEY
SOUTH FRANKLIN ST
BARNARD ST
UNION ST
LACY ST
NIELDS ST
ADAMS ST AT NIELDS ST
S. FRANKLIN ST AT LINDEN ST
NOTE; THALWEG IS A PROFILE LINE JOINING THE LOWEST POINTS ALONG A STREAM BED WHICH GENERALLY MARKS THE SLOPE OF THE STREAM THROUGHOUT ITS COURSE.
THALWEG
120+00
110+00
100+00
90+00
80+00
70+00
60+00
50+00
DISTANCE IN FEET

STORM FLOOD PLAIN LIMITS
GOOSE CREEK WATERSHED BOUNDARY
GOOSE CREEK
INDEX STA. 1
INDEX STA. 2
INDEX STA. 3
INDEX STA. 4
GARFIELD STREET
BOLMAR
WORTHINGTON
POPLAR
PENN CENTRAL RAILROAD
EAST BRANCH
Bridge
150
615
335
110
390
540
440
880
1320
SCALE




2

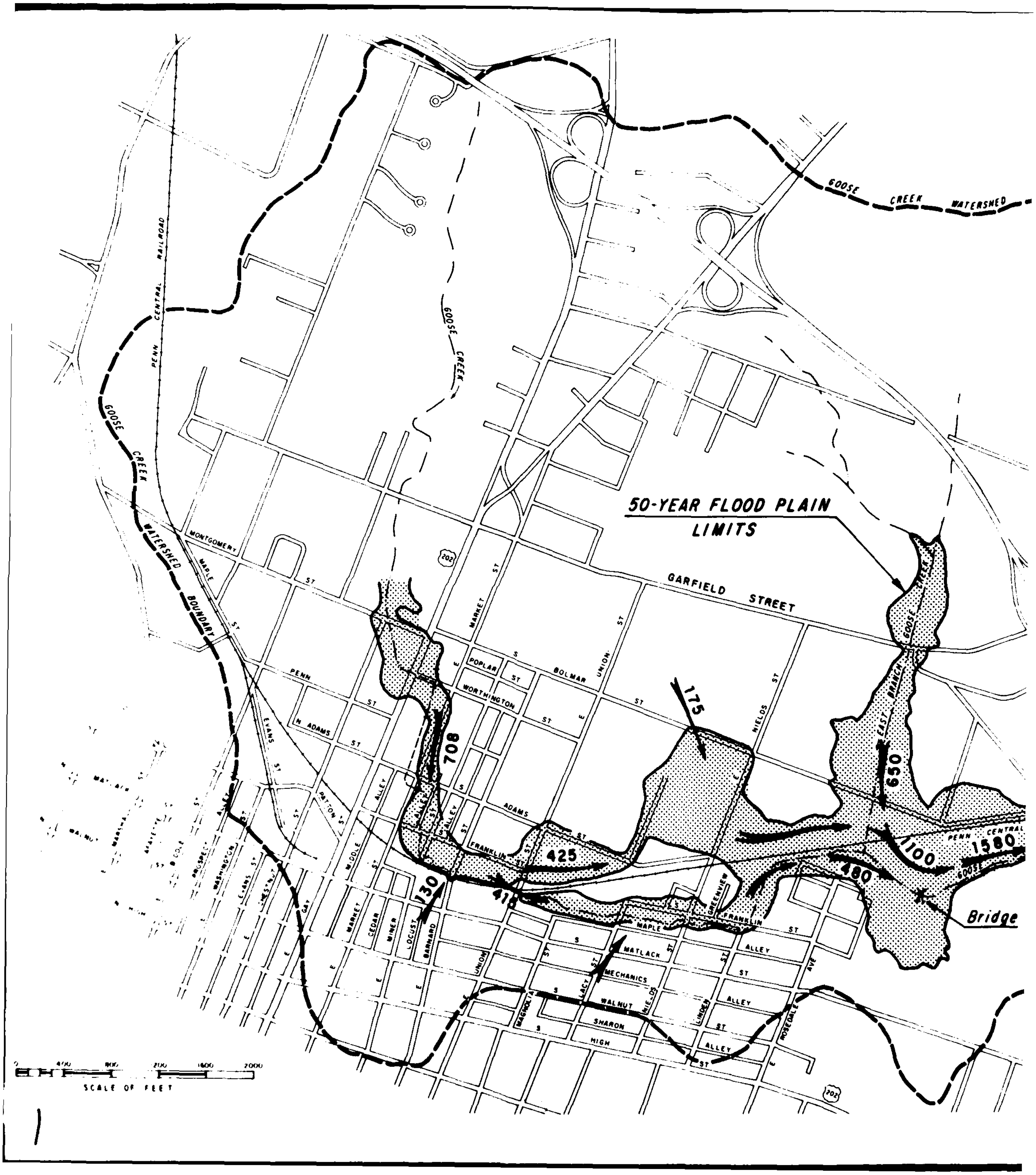
CHESTER CREEK BASIN, PENNSYLVANIA

SEPTEMBER 1971 STORM

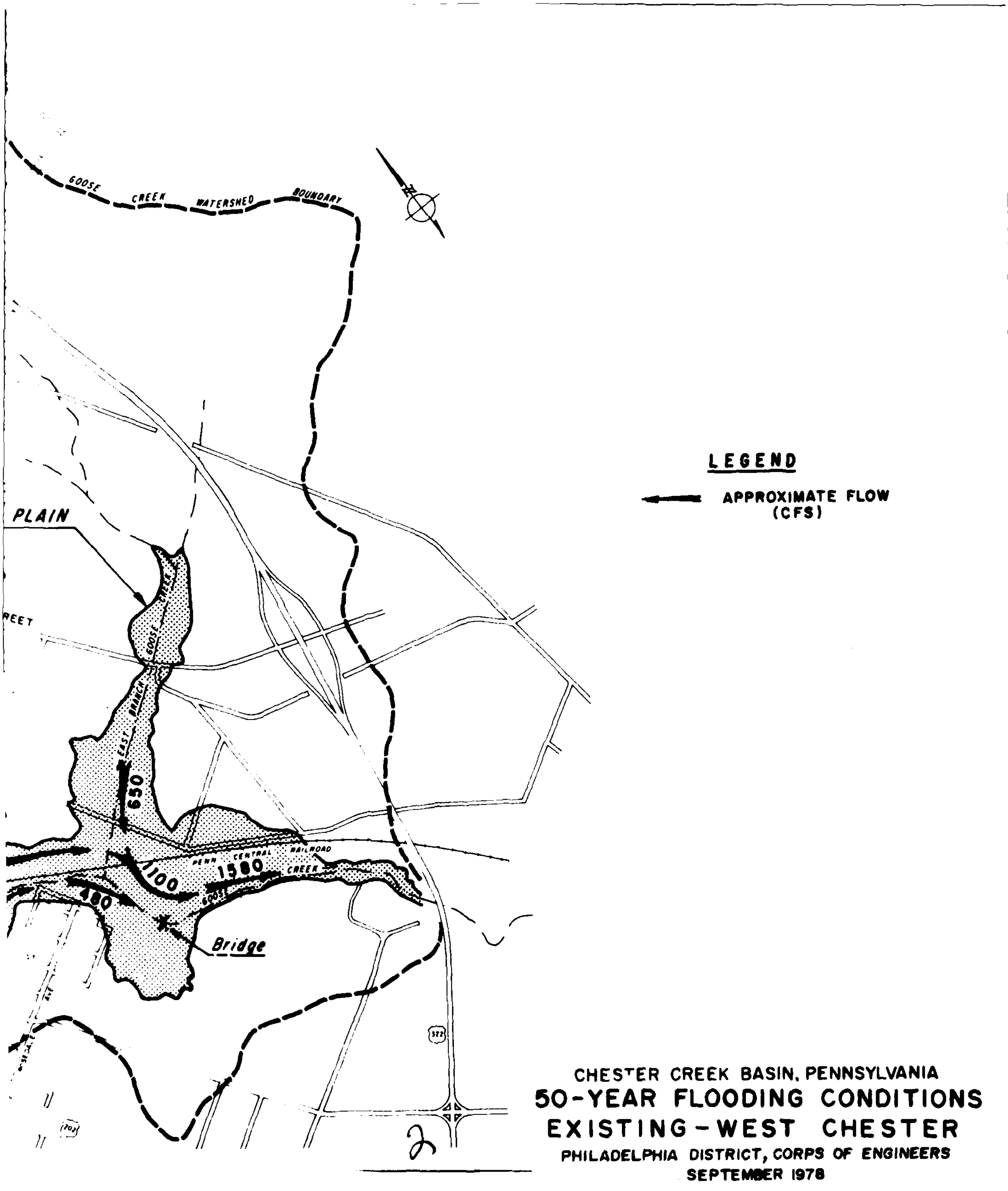
FLOODING CONDITION - WEST CHESTER

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SEPTEMBER 1978

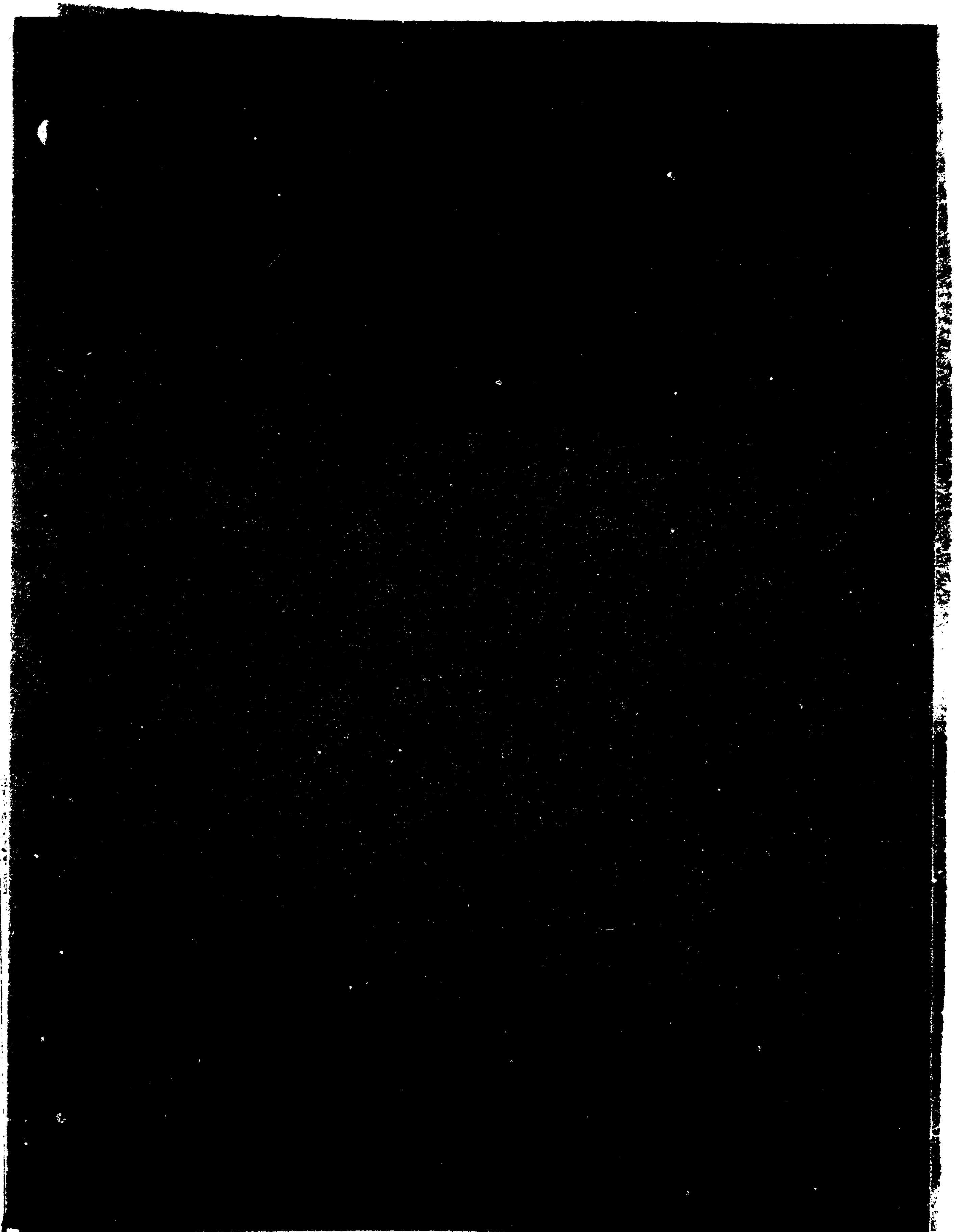


50-YEAR FLOOD PLAIN LIMITS
GOOSE CREEK WATERSHED
GOOSE CREEK WATERSHED BOUNDARY
GOOSE CREEK
PENN CENTRAL RAILROAD
EAST BRANCH GOOSE CREEK
GARFIELD STREET
Bridge
708
175
650
425
415
130
480
1100
1580
SCALE OF FEET




CHESTER CREEK BASIN, PENNSYLVANIA
50-YEAR FLOODING CONDITIONS
EXISTING-WEST CHESTER
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

2



SECTION G

# URBANIZATION ANALYSIS

1. The urbanization analysis included a prediction of the amount, character, and distribution of future development in the Basin. The analysis predicted changes in Basin hydrology and hydraulics. As land uses change, so do the Basin's stormwater runoff characteristics, (ie: frequency of flooding, flood heights). These differences were reflected in the analysis by changing imperviousness factors and runoff coefficients.

2. This information has several uses. By computing changes in flood heights over time a true representation of future damages can be made. Flood control projects can be designed to continually provide the proper level of protection. This information can also provide guidance for proper development of both flood plain and non-flood plain lands.

## OVERVIEW OF THE ANALYSIS

3. The analysis was conducted with available information. Historical development since 1940 was traced by the use of U.S. Geological Survey (USGS) quadrangles; historical mapping; age and types of existing structures; and historical documentation. Existing development (1970) was inventoried with the use of data banks and publications of the Delaware Valley Regional Planning Commission (DVRPC), the Delaware County Planning Commission (DCPC), the Chester County Planning Commission (CCPC), and local municipalities. Future growth estimates (1980-2020) were based on land use projections made by DVRPC, DCPC and CCPC; other related studies by Federal and State agencies; and on translations of historical development and future population projections into land requirements. As discussed later in this section, two futures (full and limited growth) were projected to represent probable development conditions in the Basin. These futures were used in measuring "without" project conditions. The urbanization analysis, hydrologic and hydraulic studies were conducted on both futures. The limited growth future was ultimately selected as the "most probable future." The selection of this future was based on urban planning, hydrologic, and economic considerations.

## QUALIFICATION OF THE ANALYSIS

4. The futures projected in this urbanization analysis were conducted only to predict changes in socio-environmental conditions and Basin hydrology. These projections are not meant to serve any other purposes. They are not meant to govern development, nor to reflect proper or desired planning.

## ASSUMPTIONS

5. The analysis was based on fundamental assumptions that are presented in the following paragraphs. Any assumptions made for full growth and limited growth futures on an individual basis will be discussed in later sub-sections.

Flood Plain - All flood plain development will conform completely with the Federal Disaster Protection Act of 1973 (Public Law 93-234); no future development will occur in the floodway, and no development in the flood plain unless the lowest floor (including basements) of a building is elevated to the 100-year level for residences or flood proofed to that level of non-residences. Developments planned in flood plains will incur increased costs for land treatment or flood proofing. The increased costs will deter development of flood plains and encourage development of flood free areas.

Poor Soils - No major development will be allowed in poorly drained soils unless the area is serviced by a sewerage system. Poor foundation soils will require additional land treatment costs, thus reducing their attractiveness for development. Poor foundation soil areas will be among the last to be developed.

Steep Slopes - Slopes over 25 percent will provide a major constraint to development. Little or no development will be allowed in these areas. Slopes from 15 to 25 percent will require increased land treatment costs for development. Development of any lands with over 15 percent gradients will meet with opposition from both professional planners and conservationists. For these reasons, lands with 15 to 25 percent slopes will be among the last to be developed, and land with over 25 percent was assumed not to be developed.

Parks and Open Areas - The land use of previously established parks and open spaces will remain unchanged. This category includes public parks, playgrounds, and recreation areas; conservation or nature areas which are public or owned by non-profit organizations; and

botanical gardens or arboretums which are public or owned by non-profit organizations. Private recreation areas such as amusement parks, private open areas, and cemeteries were not considered absolute constraints to development in those areas.

Zoning - Municipal zoning in the 21 communities in the Basin was considered to be the guide to future development patterns. Zoning was assumed to reflect the community's intentions on future development. In general, the more intense land uses such as industrial, commercial, and high density residential uses were considered firm land use commitments. However, less intense uses such as single family residential and agricultural uses could be altered to accommodate distant (future), high intensity land requirements.

## LAND USE CATEGORIES

6. Land use classifications were defined to suit the urbanization analysis. The classifications used are:

| | | |
|---|---|---|
| Residential I | - | .67 to .99 units per acre |
| Residential II | - | 1.0 to 4.9 units per acre |
| Residential III | - | 5.0 to 8.9 units per acre |
| Residential IV | - | 9.0 to 16.9 units per acre |
| Residential V | - | greater than 16.9 units per acre |
| Commercial | | |
| Industrial | | |
| Right-of-Way (roads and streets) | | |
| Open Space | | |

The Open Space classification includes woodlands, farmlands, very low density residential/agricultural areas, cemeteries, parks, school playing fields, and other areas with high perviousness. The Right-of-Way classification mostly includes streets, highways, and parking lots.

## RESIDENTIAL PATTERNS

7. Population and household compositions and preferences dictate the housing and residential patterns of the study area. These factors have undergone major changes in recent years. The family formation rate increased, and household size decreased between 1960 and 1970. These trends are continuing. Children are becoming independent at an earlier age, older people are maintaining their own households instead of moving in with their children, young adults of the post World War II baby boom are forming their own families and the birth rate has declined. The result is that family size has decreased and the number of households being formed from the population has increased. Between 1960 and 1970

the average household size decreased from 3.57 persons to 3.33 in Chester County and from 3.41 to 3.25 in Delaware County. All indications point to a continuation of these trends, which means an increase in the demand for housing. Based on these trends the average household size in the bi-county area is expected to approach 3 persons within the next 10 years (by 1988).

8. The communities lying totally or partially within the Chester Creek Basin are characterized by differing patterns of residential growth. The City of Chester, Upland, Parkside, Chester Township, and West Chester are the more established communities and are experiencing the slowest rates of residential growth. Much of the housing in these areas is more than thirty years old and little vacant land remains. Many of the housing units need to be replaced or renovated. The remainder of the Basin communities are experiencing rapid growth and are among the most rapidly urbanizing areas in Delaware and Chester Counties. Communities that presently have large amounts of vacant land will probably undergo an extremely rapid rate of development. The Delaware County Planning Commission expects the less-densely developed western portion of Delaware County to record high growth rates and base population increases in the next two decades.

9. According to the Delaware and Chester County Planning Commissions there is relatively little housing available for sale in the Basin. Most housing within the means of low and moderate income families is concentrated in the older, urbanized section of the Basin around the City of Chester and the Borough of West Chester. Twin, duplex, and row housing is also concentrated in these areas. The structural condition of some of the lower-priced units may be questioned, as many of them are 30 or more years old and of low value ($15,000 or less). In the City of Chester many homes are over 50 years old. According to local builders and realtors, new single family detached homes or row homes cannot be built and sold at a price within the reach of low or moderate income families.

10. Natural features, governmental structures, and construction costs are all barriers to the production of new housing. The costs of labor and materials, and the availability of money follow national trends and cannot be easily influenced by local policies. In constrast, land availability, zoning, and subdivision and building codes are subject to county and local government policies. These four factors are important to residential construction and were considered in this analysis.

## COMMERCIAL PATTERNS

11. The past and present patterns of commercial activity in Delaware and Chester County provide a basis from which to evaluate the need and distribution of future commercial development. The locations of the 6

major commercial centers in the Basin are shown on Plate G-1. The historical pattern of business activity has included centers offering activities for either regional, sub-regional, or community level markets. Higher level business activity in the Chester Creek Basin had always been centered in the older type Central Business Districts (CBD) of the City of Chester and Borough of West Chester. After World War II, commercial and service activities began to stretch out along major radial highways. Substantial retail concentrations developed at intersections of these radials and major north-south roads. More recently, some of these north-south roads themselves have undergone intense commercial development.

12. Commercial centers in the Basin are the City of Chester CBD, Granite Run Mall, and the Borough of West Chester CBD. The Chester City CBD is one of the oldest major business centers in Delaware County. It was once the County's commercial hub but has declined in recent years. Portions of the area are in varying stages of redevelopment. Granite Run Mall is a new shopping center in Middletown Township. The West Chester CBD is an old business area that is being revitalized. Individual community centers provide goods through full-line drug stores, clothing stores, and jewelry shops. These businesses are located along highways throughout the Basin. Neighborhood centers mainly provide convenience goods and include grocery stores, gas stations, and beauty shops. They are located throughout the Basin along highways and within residential areas.

13. The extent of growth and location of future commercial centers depends largely on consumer demand. The basic unit of consumer demand is the household, thus population projections were translated into households. An estimated 3.08 persons per household were used in the analysis for during and after 1980. The growth in households will create new consumer demand for retail activities. Most new commercial development will be spacially associated with this household and population growth.

## INDUSTRIAL PATTERNS

14. Industrial growth is less sensitive to conditions and growth rates within the study area than are residential or commercial patterns. This is because broad regional and national needs usually dictate the demand for most industrial products, and the market for a product. Once an industry decides to locate or expand within the Delaware Valley Region, then more immediate factors influence decisions as to where to locate. Factors such as accessibility, land use zoning, and availability of water are important in deciding on the actual location for plant facilities. The location could be anywhere within the Region.

15. The analysis of industrial patterns viewed Delaware and Chester Counties as part of the larger Philadelphia region. While changing

technology, life styles, and the real estate market may shift these patterns, it is likely that the general structure of industrial activity will remain basically as it is today. Industries in the Basin are stable. One of the oldest industrial areas in the bi-county area, and some of the newest, are located along Chester Creek as shown on Plate G-2. Existing industrial centers in the Basin are in Upper Chichester and Chester Townships, the City of Chester's Delaware River waterfront, Lenni Mills, Aston Township, West Chester Borough, and West Goshen Township.

16. The number of facilities and the amount of land likely to be needed to accommodate new industrial development or relocation of existing industrial development depends upon several factors. These include employment and income production projections. Income production can be measured by wages and salaries, capital expenditures, value of production, and value added by manufacture. In recent years, Delaware County has maintained a constant value of production but has had a decrease in wages and salaries and value added. Chester County has had a rise in value added, value of production, and wages and salaries.

17. Between 1970 and 1980 total employment is expected to increase by about 20% in Delaware County and by about 30% in Chester County. In addition to the continuing increase in total employment, the occupational makeup of the labor force is changing. The percentage of white collar workers rose by five percent in Delaware County and by nine percent in Chester County between 1960 and 1970.

18. Most of the existing industrial centers have room for expansion. When major industrial growth occurs, development will first take place in the existing industrial parks and proposed industrial areas already located in the Basin. One such area is in Middletown Township adjacent to Granite Run Mall, and another is at Painters Crossroads in Concord and Birmingham Townships. Other areas are in Thornbury Township (Delaware County, East Goshen Township , and West Goshen Township.

## COMPUTATION METHODOLOGY

19. Estimated acreages of land uses in the Basin were computed both from published data and from direct measurements of maps. The fourteen hydrologic sub-basins were the basis for computations. Zoning, land use, steep slopes, flood plains, and other information were quantified for historic, existing and projected periods. The projected data was computed for 1970 through 2020 by decade. All computations were developed by sub-basin and by municipality. The methodologies used to project commercial, industrial, residential, open space, and right-of-way land use for full and limited growth conditions are shown in Plates G-3 through G-7.

# LAND USE PROJECTIONS

20. Table G-1 summarizes land use in acres for both full and limited growth futures in the Basin by estimated acreages for 1940 and for each decade from 1970 through 2020. The estimates are given for each land use classification.

## HISTORIC LAND USE

21. In order to gain more knowledge of urbanization in the Basin, it was decided to investigate a period in the Basin before the automobile made a major impact. This era would predate the highway and parking lot boom that accounts for a major portion of impervious acreage. The year 1940 was selected for study. Residential, commercial, and industrial land use was estimated by using some historical local maps and U.S. Geological Survey maps. The maps were used to delineate developed areas. Right-of-way acreages were then estimated by using average right-of-way factors. The remaining land in the Basin was categorized as open space.

22. Land use information for the year 1940 ("pre-auto" Chester Creek Basin) is shown on Plate G-8. The 1940 land use shows most of the pre-auto residential, commercial, and industrial activities are at the two transportation hubs in the Basin, the City of Chester and the Borough of West Chester. The remainder of the Basin was primarily agricultural except for intermittent locations of groups of housing, mills, and manufacturing plants. The Basin's land use was about 4.1% residential, 0.4% commercial, 0.4% industrial, 1.5% right-of-way, and 93.6% open space.

23. The mills were primarily textile mills which were in existence prior to 1940. Since 1940, almost all the mills have closed or relocated outside of the Philadelphia region. The manufacturing plants were either constructed for manufacturing or were plants converted from old mills. The mills and manufacturing plants were initially located for their proximity to required natural resources, water power, or process water. The initial uses of the mills and plants have changed and the existing structures have been modified, many for light industrial use. Since 1940, some of these buildings have been abandoned.

## EXISTING LAND USE

24. A determination was made of existing land use in the Chester Creek Basin in 1970. This information was used as a base from which the two

TABLE G-1
SUMMARY OF LAND USE
CHESTER CREEK BASIN
(AREAS)

| YEAR | Growth F= Full L= Limited | LAND USE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Residential | | | | | | | | | |
| | | I | II | III | IV | V | Commercial | Industrial | Right-of-Way | Open Space | Totals |
| 1940 | - | 904 | 446 | 18 | 208 | 175 | 188 | 181 | 644 | 39,988 | 42,752 |
| 1970 | - | 3,268 | 3,167 | 320 | 363 | 210 | 580 | 723 | 2,025 | 32,096 | 42,752 |
| 1980 | F | 5,929 | 6,250 | 545 | 474 | 241 | 784 | 1,309 | 2,574 | 24,682 | 42,752 |
| | L | 3,724 | 4,778 | 777 | 401 | 212 | 600 | 1,309 | 2,216 | 28,737 | 42,752 |
| 1990 | F | 8,220 | 9,200 | 604 | 493 | 278 | 890 | 1,898 | 3,169 | 18,000 | 42,752 |
| | L | 4,223 | 6,362 | 1,313 | 447 | 228 | 624 | 1,898 | 2,460 | 23,197 | 42,752 |
| 2000 | F | 9,400 | 10,803 | 644 | 512 | 291 | 1,015 | 2,484 | 3,701 | 13,902 | 42,752 |
| | L | 4,703 | 7,443 | 1,578 | 605 | 249 | 598 | 2,484 | 2,657 | 22,435 | 42,752 |
| 2010 | F | 10,103 | 11,667 | 693 | 520 | 297 | 1,071 | 2,872 | 4,141 | 11,388 | 42,752 |
| | L | 4,823 | 7,679 | 1,839 | 834 | 287 | 671 | 2,939 | 2,835 | 20,845 | 42,752 |
| 2020 | F | 10,556 | 12,174 | 737 | 527 | 312 | 1,120 | 3,265 | 4,576 | 9,485 | 42,752 |
| | L | 4,917 | 7,897 | 2,020 | 1,064 | 321 | 694 | 3,419 | 3,005 | 19,415 | 42,752 |

1/ Total basin area computed by summing sub-basin areas which were planimetered; the total is approximatly 1.6% less than the 67.9 sq. mi. area of the basin due to inaccuracy and rounding, but this error is distributed throughout the sub-basin and land uses and is not important to the results of the analysis.

alternative future land use projections were made. Existing land use acreages were based mainly on the Delaware Valley Regional Planning Commission's 1970 land use "file" data and county land use maps and "file" data for 1970.

25. A composite of existing zoning and existing land use maps are presented on Plates G-9 and G-10, respectively. The composite zoning maps were developed from individual municipal zoning maps. The existing land use map, which is basically 1970 data, was developed from regional and county maps and file data.

26. As can be seen from Plate G-9, most of the communities are zoned for single-family residential units with large lots. Also, there appears to be an overabundance of commercially and industrially zoned lands. Although the total acreage of land seems to be sufficient for future needs, the geographical distribution of the different zoning areas may not be entirely satisfactory.

27. The existing land use map, Plate G-10, shows that while denser development has occurred near the City of Chester and the Borough of West Chester, there is considerable development throughout the Basin. This is of a sporadic or "leapfrog" nature, resulting in patches of development and intermittent patches of open space. The Basin's land use is about 17.1% residential, 1.4% commercial, 1.7% industrial, 4.7% right-of-way, and 75.1% open space. This is an increase of 318% in residential use, an increase of 209% in commercial use, an increase of 299% in industrial use, an increase of 214% of right-of-way use, and a decrease of 20% in open space between 1940 and 1970.

## FUTURE LAND USE - FULL GROWTH

28. The full growth future was computed as outlined on Plates G-3 through G-5. The future was based on the general assumption that by the year 2000 most of the lands available for residential development will accommodate this residential growth and continue to develop according to recent historical patterns. Industrial growth projections were based on the premise that the rate of industrial development in the Basin communities would increase over current trends. This would happen because of the Basin's opportunity for industrial park-type development. Right-of-way acreages were projected on the basis of existing right-of-way acreages and average factors for right-of-way requirements. All residual land was classified as open space. Redistributions were then made to insure that minimum open space requirements were met.

29. Full growth projections were basically the distribution of regional and county projections. These projections were made to show the effects on imperviousness of the urbanization which has been planned for by DVRPC and the county planning commissions. The full growth future land use

map which was developed from the projections is presented on Plate G-11. In the year 2020 these projections call for the Basin's land use to be about 56.8% residential, 2.6% commercial, 7.6% industrial, 10.7% right-of-way, and 22.3% open space. This is an increase of 232% in residential use, 93% in commercial use, 352% in industrial use and 126% in right-of-way use, and a decrease of 70% in open space between 1970 and 2020.

## FUTURE LAND USE - LIMITED GROWTH

30. The analysis of the limited growth future was computed as outlined on Plates G-5 through G-7. The future was based on the general assumptions that the projected Basin population up to the year 2020 is correct, but the distribution within each municipality in the Basin is not an absolute constraint. Therefore, redistribution could accommodate other constraints such as steep slopes or flood plains. Commercial development will accommodate the residential growth and continue to expand according to historical patterns. Industrial growth projections were based on the assumption that industrial land use in the Basin communities will increase slightly because of the Basin's opportunity for industrial park-type development.

31. Another general assumption is that steep slopes, flood plains, and unsuitable soils will not be developed except as a last resort. It is assumed that population will shift within the Basin to an area where it can be readily accommodated. Residential lands will be rezoned to allow denser development when required. After residential, commercial, and industrial land use projections were made, right-of-way land use projections were made in a manner similar to that of the full growth analysis. Undevelopable lands (flood plain, steep slope, and poor soil lands) were used for right-of-way in some cases but were generally considered to be part of the Basin's open space. Residual developable land was classified as open space.

32. The limited growth analysis allowed for essentially the same population and economic growth as did the unlimited growth analysis. The basic difference is that the development will be of a denser nature. Because of restrictions on developing certain lands, housing lots would be smaller and more multi-unit residences would be permitted. Available commercial and industrial lands would be utilized. This would result in more concentrated future development with greater open space acreages than in the full growth analysis.

33. The limited growth projections resulted from population redistributions resulting from constraints to development which the regional and county planning agencies did not consider. The total Basin population is the same for both futures but the distribution within the Basin is different. Table G-1 summarizes land uses for each land use category. This is done for each decade from 1970 through 2020. The limited growth

future land use map is presented on Plate G-12. In the year 2020 these projections call for the Basin's land use to be about 37.9% residential, 1.6% commercial, 8.0% industrial, 7.0% right-of-way, and 45.5% open space. This is an increase of 121% in residential use, 197% in commercial use, 373% in industrial use, and 48% in right-of-way use between 1970 and 2020 and a decrease of 40% in open space.

## MOST PROBABLE FUTURE

34. Limited growth was selected as the most probable future and was used for plan formulation and evaluation. This selection was based on the current trends toward more controlled growth, smaller families, denser housing, and greater public awareness of the problems related to rapid urbanization.

35. In the selection process most of the hydrology, hydraulics, and some of the economic studies were done for both futures. This was to determine the sensitivity between these futures. The items which were considered and tested prior to making the selection of limited growth as the most probable future are discussed in the following paragraphs.

## SENSITIVITY OF PROJECTIONS

36. The five basic assumptions in this urbanization analysis were for flood plains, soils, steep slopes, parks and open areas, and zoning. The difference between full and limited growth in projections and/or distributions of population, households, and land uses resulted primarily from the following differences within the five basic assumptions:

Limited growth does not accommodate all the individual projected population and household growth within each individual municipality for which it was projected, but let it cross municipal boundaries within the Basin boundaries. Full growth does accommodate all population and household growth in the municipality for which it was projected.

Limited growth accommodates increased residential development at the most dense development allowed by local zoning. This will concentrate residential developments. Full growth assumes the least dense development allowed by local zoning will take place. This will tend to spread out residential developments.

Limited growth allows projected economic growth to take place but utilizes more concentrated development of new commercial and industrial lands and redevelopment of existing lands. Full growth assumes that new commercial and industrial developments will not be more concentrated.

Limited growth assumes a strict adherence to no development on poor soils, steep slopes, and flood plains. (This is in compliance with good planning principles and with what both county planning commissions are presently promoting.) Full growth assumes that developments will be built as shown on existing plans, no matter if in flood plains, or if on poor soils or steep slopes.

Limited growth assumes that as the Basin becomes more urbanized the demand for open spaces, public parks, preserves, and recreation areas becomes greater. Limited growth calculations contain greater amounts of this type of land than current land use plans allow. (This is a microscopic or Basin application of what present trends indicate to be happening on a regional basis.) Full growth assumes that only areas currently planned as parks or other open space will remain open.

37. Population projections developed by the county and regional planning commissions were used for both futures. The differences between the two futures was in the distribution of the population and household throughout the Basin. This difference in distribution had its greatest impact in differences in residential and open land uses. The full growth future has 9916 more acres of Residential I and II use in 2020 than the limited growth future and has 9330 less acres of open space. The fact that more undeveloped land results from the limited growth analysis may well reflect national trends. In the last five years, both population and new housing starts have declined on a national basis. In addition, in the Philadelphia region, more people are accepting the fact of smaller more concentrated housing. This is not necessarily out of preference but out of economic necessity because of the cost of housing.

38. With respect to the differences in assumptions which affect commercial and industrial land use, the limited growth analysis allowed what was considered a more "desirable" land use without sacrificing economic growth or tax base. The result was small differences in commercial and industrial land uses (426 acres and 154 acres, respectively in 2020).

## HYDROLOGIC AND HYDRAULIC SENSITIVITY

39. The hydrology and hydraulic effects of both full and limited growth on stormwater runoff were analyzed assuming the following:

no future development would occur in stream floodways;

development in the remainder of the flood plain would not increase backwaters; and

no floodwater or flood plain management projects or programs (other than those stated above) would be developed during the period of analysis (1970-2020).

Normally flood plain ordinances permit a one-foot increase. Attempting to consider this one-foot increase was not considered warranted for this study. Use of a no increase conditiion simplified calculations.

40. As shown on Tables G-2 and G-3, the difference in stream discharges and stages between the full and limited growth futures were small. The increases in discharges and stages themselves were more sensitive within the individual future. For example, between the years 1970 and 2020 the 50-year discharge increases from 16,000 cfs to 19,000 cfs with limited growth and to 19,650 with full growth. The 50-year stage at the USGS gage increases from 44.8 feet to 46.8 feet with limited growth and to 47.2 feet with full growth.

41. The limited growth does result in slightly smaller increases in runoff. However, it is felt that in the future some of the larger residential, commercial, and industrail developments in both Chester and Delaware Counties will provide for either partial or total on-site detention of increased storm water runoff due to the development. The more conservative approach used in limited growth would hopefully offset any possible overestimate of increased runoff.

## ECONOMIC SENSITIVITY

42. The use of the limited growth hydrology consequently resulted in a lower estimate of increased damages due to future urbanization. This then resulted in the lower estimate of benefits. Likewise, this conservative approach would offset any projected increased urbanization benefits which could be reduced by on-site detention.

TABLE G-2
COMPARISON OF DISCHARGE
FULL AND LIMITED GROWTH FUTURES
CHESTER CREEK BASIN 1/

| Event | Land Use | Year 1970 | 1980 | 1990 | 2000 | 2010 | 2020 | Difference 2020-1970 |
|---|---|---|---|---|---|---|---|---|
| SPF | Full (F) | 35,800 | 36,840 | 37,880 | 38,920 | 39,970 | 41,000 | 5,200 |
| | Limited (L) | 35,800 | 36,830 | 37,860 | 38,890 | 39,920 | 40,930 | 5,130 |
| | F-L | 0 | 10 | 20 | 30 | 50 | 70 | |
| 100 | Full (F) | 20,300 | 21,040 | 21,780 | 22,520 | 23,270 | 24,000 | 3,700 |
| | Limited (L) | 20,300 | 21,010 | 21,720 | 22,430 | 23,140 | 23,840 | 3,540 |
| | F-L | 0 | 30 | 60 | 90 | 130 | 160 | |
| 50 | Full (F) | 16,000 | 16,830 | 17,660 | 18,390 | 19,020 | 19,650 | 3,650 |
| | Limited (L) | 16,000 | 16,700 | 17,400 | 18,000 | 18,500 | 19,000 | 3,000 |
| | F-L | 0 | 130 | 260 | 390 | 520 | 650 | |
| 10 | Full (F) | 8,090 | 8,770 | 9,450 | 10,130 | 10,820 | 11,500 | 3,410 |
| | Limited (L) | 8,090 | 8,640 | 9,190 | 9,740 | 10,290 | 10,840 | 2,750 |
| | F-L | 0 | 130 | 260 | 390 | 530 | 660 | |

1/ Discharges at USGS Gage 4770 at Dutton Mill Road, Chester Township. Discharges in cubic feet per second (cfs)

TABLE G-3
COMPARISON OF WATER SURFACE ELEVATION
FULL AND LIMITED GROWTH FUTURES
CHESTER CREEK BASIN 1/

| Event | Land Use | Year 1970 | 1980 | 1990 | 2000 | 2010 | 2020 | Difference 2020-1970 |
|---|---|---|---|---|---|---|---|---|
| SPF | Full (F) | 54.0 | 54.3 | 54.6 | 54.9 | 55.2 | 55.5 | 1.5 |
| | Limited (L) | 54.0 | 54.3 | 54.6 | 54.9 | 55.2 | 55.5 | 1.5 |
| | F-L | 0 | 0 | 0 | 0 | 0 | 0 | |
| 100 | Full (F) | 47.5 | 48.0 | 48.5 | 49.0 | 49.5 | 49.9 | 2.4 |
| | Limited (L) | 47.5 | 48.0 | 48.5 | 49.9 | 49.4 | 49.8 | 2.3 |
| | F-L | 0 | 0 | 0 | 0 | 0.1 | 0.1 | |
| 50 | Full (F) | 44.8 | 45.4 | 46.0 | 46.5 | 46.8 | 47.2 | 2.4 |
| | Limited (L) | 44.8 | 45.3 | 45.7 | 46.2 | 46.5 | 46.8 | 2.0 |
| | F-L | 0 | 0.1 | 0.3 | 0.3 | 0.3 | 0.4 | |
| 10 | Full (F) | 38.6 | 39.3 | 40.0 | 40.6 | 41.3 | 41.8 | 3.2 |
| | Limited (L) | 38.6 | 39.1 | 39.6 | 40.2 | 40.6 | 41.0 | 2.4 |
| | F-L | 0 | 0.2 | 0.4 | 0.4 | 0.7 | 0.8 | |

1/ Elevations at USGS Gage 4770 at Dutton Mill Road, Chester Township. Elevations in feet above Mean Sea Level Datum (MSLD).

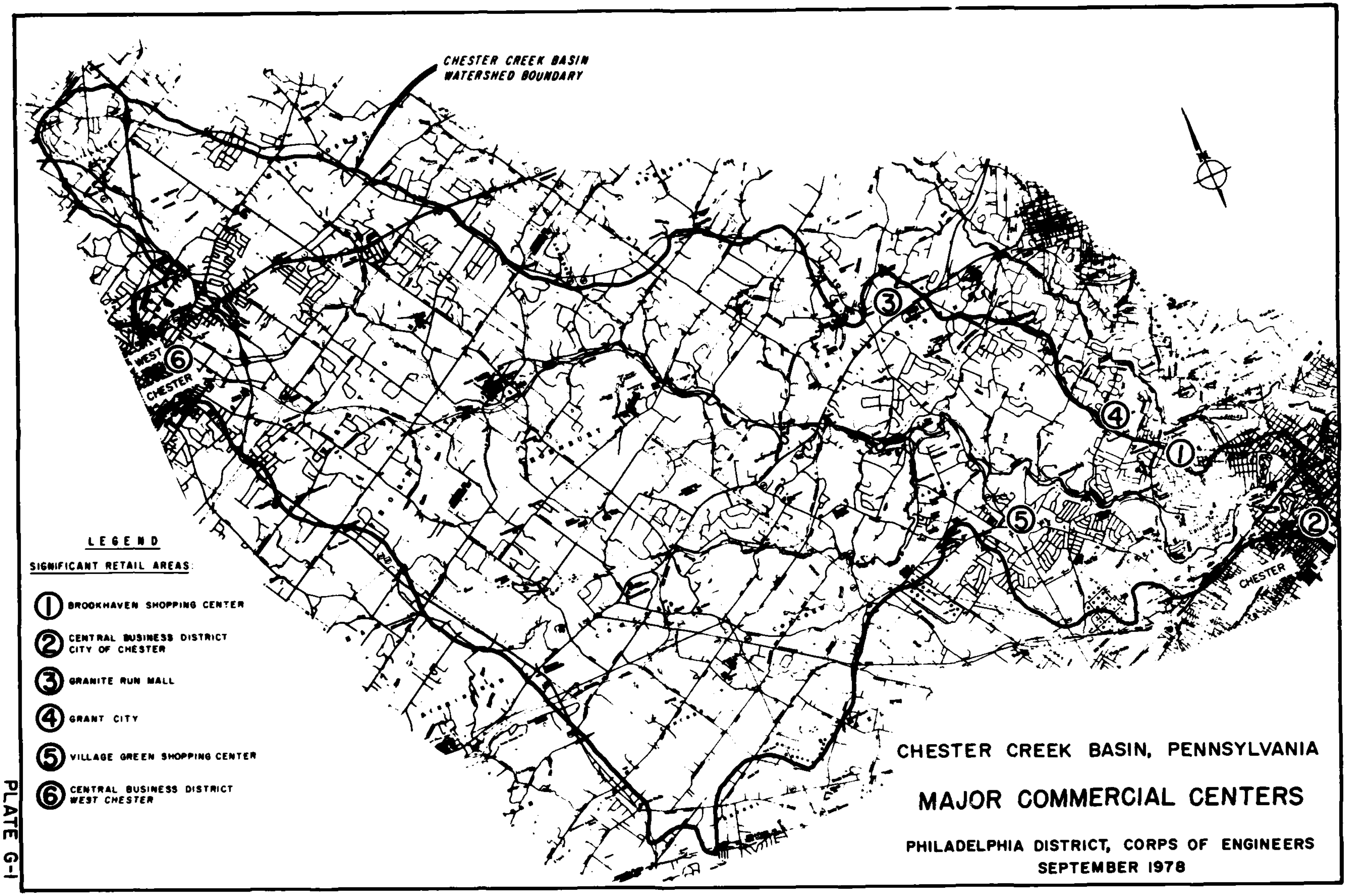

CHESTER CREEK BASIN
WATERSHED BOUNDARY
WEST CHESTER
CHESTER
LEGEND
SIGNIFICANT RETAIL AREAS:
1 BROOKHAVEN SHOPPING CENTER
2 CENTRAL BUSINESS DISTRICT CITY OF CHESTER
3 GRANITE RUN MALL
4 GRANT CITY
5 VILLAGE GREEN SHOPPING CENTER
6 CENTRAL BUSINESS DISTRICT WEST CHESTER
CHESTER CREEK BASIN, PENNSYLVANIA
MAJOR COMMERCIAL CENTERS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE G-1

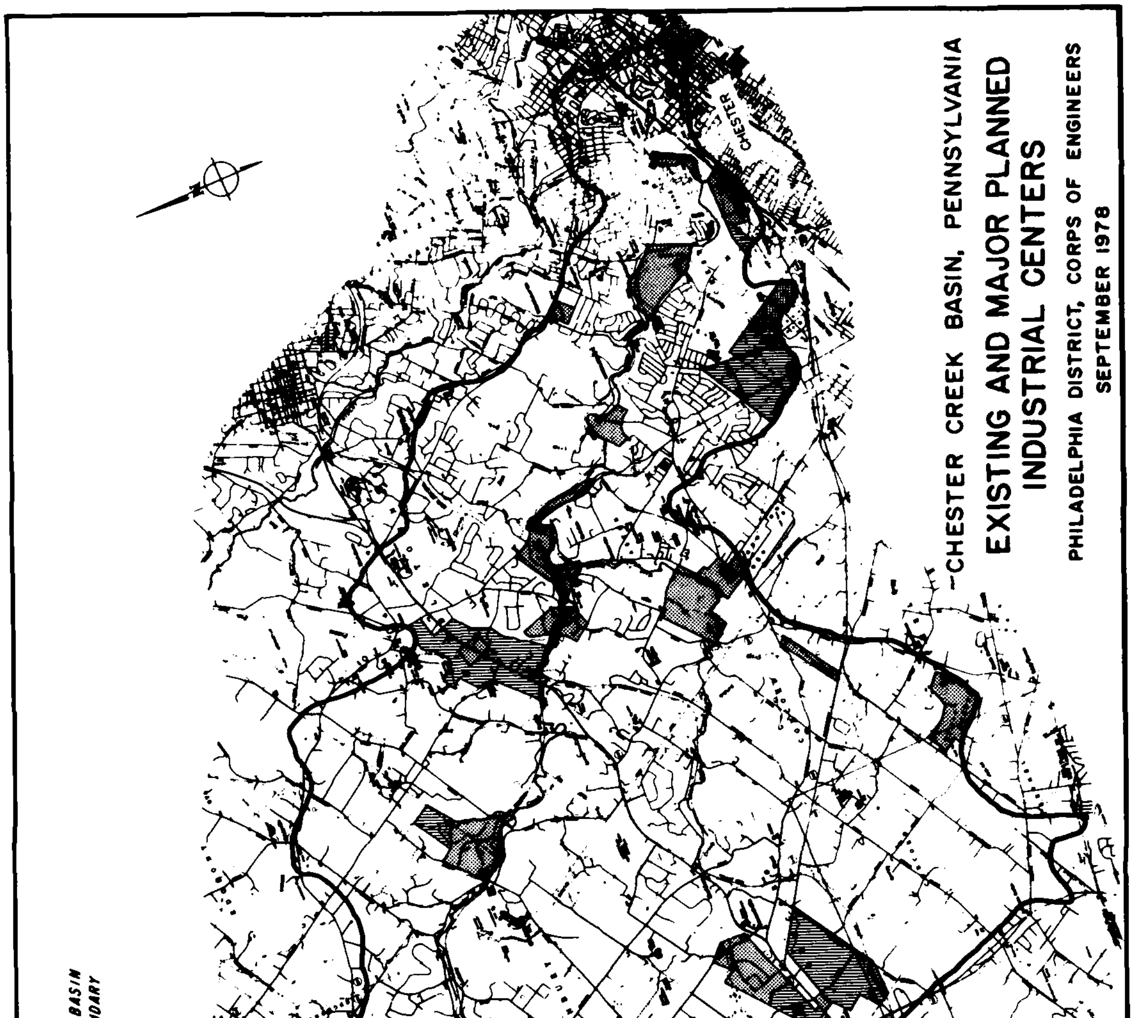
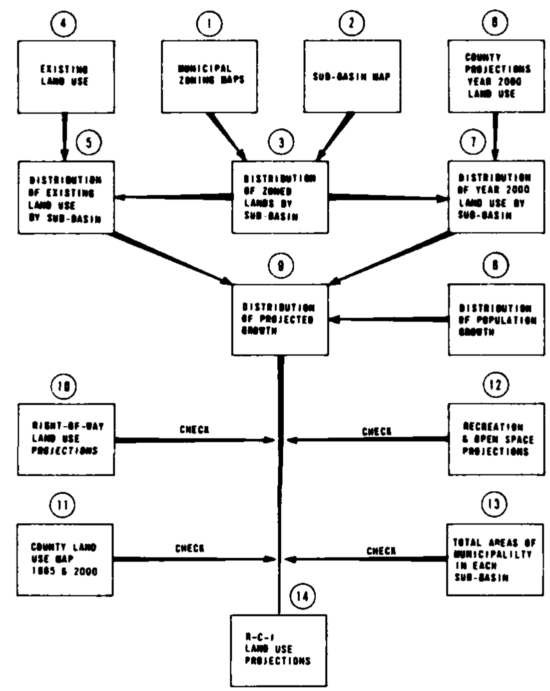

CHESTER CREEK BASIN, PENNSYLVANIA
EXISTING AND MAJOR PLANNED INDUSTRIAL CENTERS
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978
CHESTER CREEK BASIN WATERSHED BOUNDARY
CHESTER
WEST CHESTER
LEGEND
EXISTING INDUSTRIAL AREA
UNDEVELOPED OR PARTIALLY DEVELOPED INDUSTRIAL AREA

PLATE G-2




(1)(2)(3) CURRENT MUNICIPAL ZONING WAS PLOTTED ON A BASIN MAP AND ACREAGES COMPUTED FOR RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL ZONING.

(4)(5) EXISTING RESIDENTIAL, COMMERCIAL AND INDUSTRIAL LANDS WERE INVENTORIED, PLOTTED AND COMPUTED BY REVIEWING AND COMBINING REGIONAL AND COUNTY LAND USE FILE DATA WITH AERIAL PHOTOGRAPHY.

(6)(7) REGIONAL AND COUNTY PROJECTIONS FOR 1985 AND 2000 WERE USED FOR THE BASIS OF FUTURE GROWTHS. SINCE THESE WERE PROJECTED FOR AN ENTIRE MUNICIPALITY, PORTIONS IN THE BASIN WERE THEN EXTRACTED FOR EACH MUNICIPALITY BY SUB-BASIN. COMMERCIAL NEEDS WERE BASED ON POPULATION PROJECTIONS. IT WAS ASSUMED THAT REGIONAL AND SUB-REGIONAL AND NEIGHBORHOOD NEEDS WOULD BE SATISFIED BY BOTH EXPANSION OF EXISTING CENTERS AND DEVELOPMENT OF NEW ONES WITHIN THE IMMEDIATE SERVICE AREAS.

(8) POPULATION PROJECTIONS WERE THAN DISTRIBUTED FOR THAT PORTION OF THE MUNICIPALITY IN THE BASIN BY DECADE FROM 1970 TO 2020

(9) THE POPULATION GROWTH RATE WAS THE BASIS FOR ESTIMATING RATE OF RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL DEVELOPMENT BY DECADE. INDUSTRIAL GROWTH CONSIDERED NATIONAL AND REGIONAL TRENDS. LAND USE REQUIREMENTS WERE COMPUTED BY DECADE FOR EACH SUB-BASIN.

(10)(11)(12)(13) RIGHT-OF-WAY AND OPEN SPACE PROJECTIONS WERE ADDED TO RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL ESTIMATES. COUNTY LAND USE MAPS FOR 1985 AND 2000 WERE COMPARED, AVAILABLE LANDS WERE COMPARED WITH PROJECTED LAND USES TO DETERMINE IF THEY COULD ACCOMMODATE PROJECTED GROWTH. THIS WAS DONE FOR ALL OPEN LANDS. IT WAS ASSUMED THAT BASIN LANDS COULD BE REZONED TO ACCOMMODATE COMMUNITY AND NEIGHBORHOOD COMMERCIAL NEEDS. INDUSTRIAL NEEDS WOULD BE SATISFIED BY PLANNED INDUSTRIAL PARKS AND ZONED LANDS THROUGHOUT THE BASIN REGARDLESS OF MUNICIPAL BOUNDARIES.

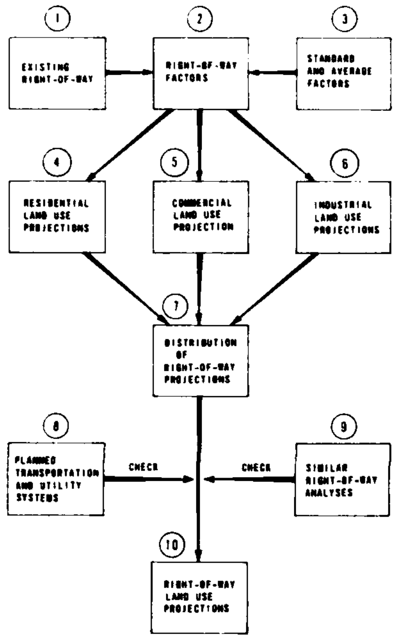
(14) CORRECTIONS AND REDISTRIBUTIONS WERE MADE AS REQUIRED FOR BALANCES BETWEEN LAND REQUIREMENTS AND AVAILABLE LANDS FOR EACH CLASSIFICATION AND TYPE.

CHESTER CREEK BASIN, PENNSYLVANIA

## METHODOLOGY FOR FULL GROWTH PROJECTIONS RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL LAND USE

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE G-3




FULL GROWTH

(1) CURRENT RIGHT-OF-WAY ACREAGE WAS COMPILED BY COMPARING AND COMBINING REGIONAL AND COUNTY LAND USE FILE DATA.

(2) STANDARD OR AVERAGE RIGHT-OF-WAY REQUIREMENTS FOR DIFFERENT TYPES OF DEVELOPMENT WERE REVIEWED; AND RELATED TO COMMON BASES SUCH AS DIFFERENT TYPES OF DEVELOPMENT AND POPULATION GROWTHS.

(3) FACTORS FOR ESTIMATING RIGHT-OF-WAY REQUIREMENTS WERE DEVELOPED FOR RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL DEVELOPMENT ANALYZING EXISTING RIGHT-OF-WAY REQUIRED FOR EXISTING LAND USE FOR EACH CLASSIFICATION. THESE WERE COMPARED WITH STANDARD/AVERAGE FACTORS FOR RIGHT-OF-WAY REQUIREMENTS.

(4) (5) (6) (7) RIGHT-OF-WAY ACREAGES WERE PROJECTED FOR FUTURE RESIDENTIAL, COMMERCIAL AND INDUSTRIAL LAND USES, BY MULTIPLYING RESPECTIVE PROJECTED LAND USES BY THE FACTORS.

(8) (9) PLANS FOR FUTURE TRANSPORTATION AND UTILITY NETWORKS WERE REVIEWED AND INCLUDED. ESTIMATES WERE COMPARED WITH OTHER SIMILAR STUDIES IN THE REGION. ADDITIONAL ADJUSTMENTS WERE MADE AS REQUIRED.

(10) PROJECTED RIGHT-OF-WAY REQUIREMENTS WERE COMBINED WITH ALL THE OTHER LAND USE PROJECTIONS. CORRECTIONS AND REDISTRIBUTIONS WERE MADE AS REQUIRED FOR BALANCES BETWEEN LAND REQUIREMENTS AND AVAILABLE LANDS.

LIMITED GROWTH

THE LIMITED GROWTH ANALYSIS WAS SIMILAR TO THAT FOR FULL GROWTH. A COMPARISON IS OUTLINED BELOW.

(1) (2) (3) SAME COMPUTATION PROCEDURE.

(4) (5) (6) (7) SAME COMPUTATION PROCEDURE, BUT RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL ACREAGES DIFFERED.

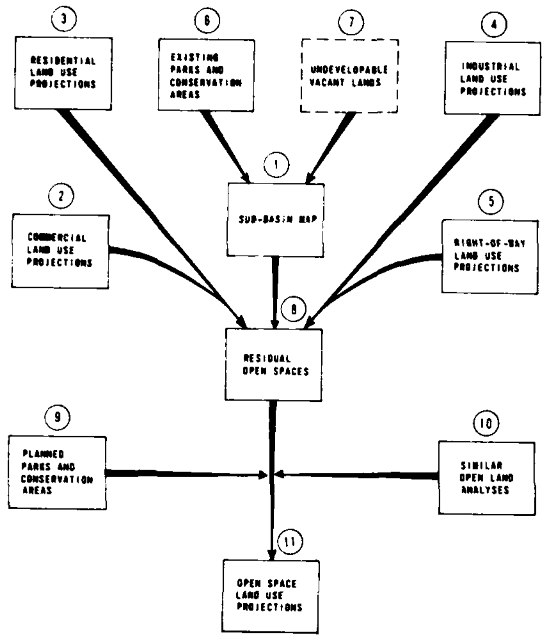
(8) (9) SAME ADJUSTMENTS WERE MADE.

(10) PROJECTED RIGHT-OF-WAY REQUIREMENTS WERE ALSO COMBINED WITH ALL THE OTHER PROJECTIONS. HOWEVER, NO REDISTRIBUTIONS WERE MADE. FLOOD PLAIN, STEEP SLOPE, AND POOR SOIL LANDS WERE USED FOR RIGHT-OF-WAY PURPOSES.

**CHESTER CREEK BASIN, PENNSYLVANIA**

**METHODOLOGY FOR PROJECTIONS RIGHT-OF-WAY LAND USE FULL AND LIMITED GROWTH**

**PHILADELPHIA DISTRICT, CORPS OF ENGINEERS**
**SEPTEMBER 1978**




(1)(2)(3)(4)(5)(6) ALL RESIDENTIAL, COMMERCIAL, INDUSTRIAL, AND RIGHT-OF-WAY LAND REQUIREMENTS WERE PLOTTED AND TOTALED BY DECADE. THESE WERE THEN ADDED TO TOTAL EXISTING OFFICIALS OPEN SPACES.

(7) UNDEVELOPABLE VACANT LAND ACCOUNTING WAS DONE FOR ONLY LIMITED. FLOOD PLAINS, STEEP SLOPES, AND UNSUITABLE SOILS WERE ASSUMED CONSTRAINTS TO DEVELOPMENT EXCEPT FOR RIGHTS-OF-WAY. UNDEVELOPABLE LANDS WERE CONSIDERED PART OF THE BASIN'S OPEN SPACE THROUGHOUT THE ENTIRE FUTURE ANALYSIS.

(8) RESIDUAL OPEN SPACES WERE THEN COMPUTED. CHECKS WERE RUN TO INSURE THAT TOTAL PROJECTED LAND USES DID NOT EXCEED TOTAL AVAILABLE LAND AREA OF THE MUNICIPALITY'S PORTION IN THE SUB-BASIN.

(9) RESIDUAL OPEN LANDS WERE THEN COMPARED WITH PLANNED PARKS AND CONSERVATION AREAS. THIS WAS TO DETERMINE IF TOTAL GROWTH PROJECTIONS WERE COMPATIBLE WITH PLANNED OPEN SPACES.

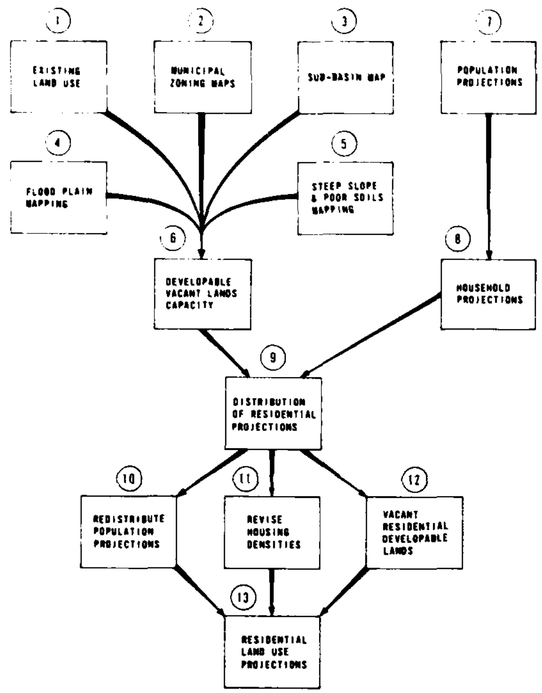
(10) FACTORS FOR STANDARD LAND USE PLANNING PRACTICES WERE USED TO DETERMINE IF ADEQUATE OPEN SPACES WERE BEING PROVIDED BY THE LAND USE PROJECTIONS. MINIMUM OPEN SPACE REQUIREMENTS WERE USED AS CONSTRAINTS TO FURTHER DEVELOPMENT. ADJUSTMENTS WERE MADE TO PROJECTED LAND USES IN ORDER TO SATISFY THESE MINIMUM REQUIREMENTS.

(11) TOTAL OPEN SPACES, OFFICIAL PLUS RESIDUAL, WERE THEN COMBINED WITH ALL THE OTHER LAND USE PROJECTIONS. CORRECTIONS AND REDISTRIBUTIONS WERE MADE AS REQUIRED FOR BALANCES BETWEEN LAND REQUIREMENTS AND AVAILABLE LANDS.

CHESTER CREEK BASIN, PENNSYLVANIA

# METHODOLOGY FOR PROJECTIONS FULL AND LIMITED GROWTH OPEN SPACE LAND USE

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978




(1) (2) (3) (4) (5) CURRENT MUNICIPAL ZONING WAS PLOTTED AND FLOOD PLAINS, STEEP SLOPES AND POOR SOILS DELINEATED.

(6) EXISTING LAND USES WERE INVENTORIED, PLOTTED, AND COMPUTED BY REVIEWING AND COMBINING REGIONAL AND COUNTY USE DATA WITH AERIAL PHOTOGRAPHY. SUITABLE (NON-FLOOD PLAIN, NON-STEEP SLOPES, OR NON-POOR SOILS) UNDEVELOPED LANDS WERE THEN DELINEATED BY ZONING CATEGORY AND AVAILABLE ACREAGES COMPUTED.

(7) (8) REGIONAL AND COUNTY POPULATION PROJECTIONS WERE USED FOR PROJECTING INCREASES IN HOUSEHOLDS. THE NUMBER OF PEOPLE PER HOUSEHOLD USED FOR THIS WAS 3.17 FOR PRIOR TO 1980 AND 3.08 FOR 1980 AND THEREAFTER.

(9) HOUSING TO ACCOMMODATE NEW HOUSEHOLDS WAS THEN PROJECTED. RESIDENTIAL GROWTH WAS THEN DISTRIBUTED TO AVAILABLE DEVELOPABLE RESIDENTIAL LANDS.

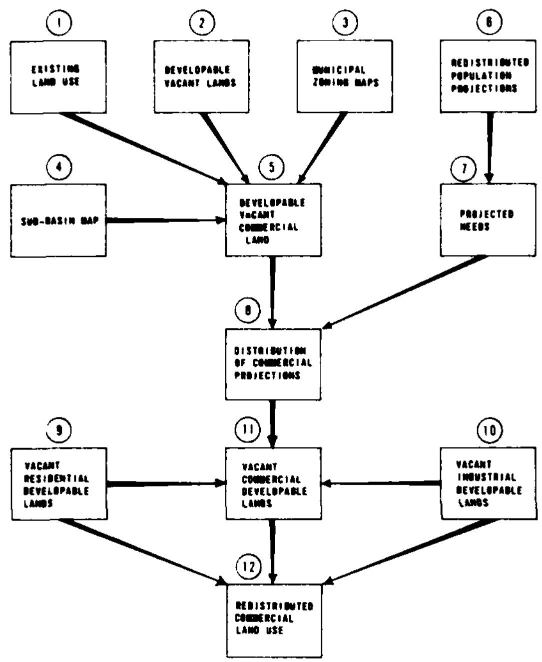
(10) (11) (12) IT WAS DISCOVERED THAT SOME COMMUNITIES COULD NOT ACCOMMODATE ADDITIONAL HOUSEHOLDS WITH EXISTING ZONING. IN THE MORE SUBURBAN COMMUNITIES, IF PEOPLE COULD NOT GET THE TYPES OF HOMES THEY WANTED IN ONE COMMUNITY, THEY WOULD BE WILLING TO GO AT LEAST AS FAR AS THE NEIGHBORING MUNICIPALITY. ONCE ALL THESE AREAS STARTED FILLING, THEN IT WAS ASSUMED THAT SOME OF THE RESIDENTIAL LAND WOULD BE REZONED IN ORDER TO ALLOW DENSER DEVELOPMENT. IN THE MORE URBAN COMMUNITIES IT WAS ASSUMED THAT THE GROWTH OF HOUSEHOLDS WOULD BE ACCOMMODATED WITHIN EACH COMMUNITY. REDEVELOPMENT WOULD MEET ALL HOUSING NEEDS THROUGH DENSER DEVELOPMENT.

(13) THE REDISTRIBUTION OF HOUSING WAS A CYCLICAL PROCESS REQUIRING CHECKS AND REFINEMENTS. ONCE THE ESTIMATES WERE BALANCED, THEN NEW POPULATION, DEVELOPED RESIDENTIAL LAND, AND VACANT RESIDENTIAL LANDS WERE COMPUTED. THESE WOULD ALSO BE USED FOR PROJECTING OTHER LAND USES.

CHESTER CREEK BASIN, PENNSYLVANIA

# METHODOLOGY FOR PROJECTIONS LIMITED GROWTH RESIDENTIAL LAND USE

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978




1 2 3 4 EXISTING LAND USE, ZONING, AND DEVELOPABLE VACANT LANDS WERE PLOTTED ON THE BASIN MAP. DEVELOPABLE LAND IDENTIFICATION WAS USED FROM THE RESIDENTIAL LIMITED GROWTH ANALYSIS.

5 DEVELOPABLE VACANT COMMERCIAL AND INDUSTRIAL LANDS WERE DELINEATED AND COMPUTED BY MATCHING COMMERCIAL AND INDUSTRIAL ZONING WITH DEVELOPABLE VACANT LANDS.

6 7 THE REDISTRIBUTED POPULATION PROJECTIONS FROM THE RESIDENTIAL LIMITED GROWTH ANALYSIS WERE USED FOR PROJECTING COMMERCIAL NEEDS. REGIONAL AND SUBREGIONAL TYPES WERE SATISFIED BY EXPANDING EXISTING CENTERS. COMMUNITY, AND NEIGHBORHOOD TYPES WOULD BE SATISFIED BY BOTH EXPANDING EXISTING CENTERS AND DEVELOPING NEW ONES WITHIN THE IMMEDIATE SERVICE AREA. INDUSTRIAL GROWTH WAS BASED ON REGIONAL AND COUNTY PROJECTIONS. ONLY PLANNED INDUSTRIAL AREAS WOULD BE DEVELOPED. EXISTING INDUSTRIAL PARKS WILL CONTINUE TO ATTRACT INDUSTRIAL GROWTH FIRST.

8 COMMERCIAL AND INDUSTRIAL GROWTHS WERE THEN DISTRIBUTED. IF COMMERCIALLY ZONED LANDS WERE NOT AVAILABLE, IT WAS ASSUMED THAT ZONING WOULD BE CHANGED TO ACCOMMODATE NEIGHBORHOOD COMMERCIAL NEEDS. ALSO COMMUNITY COMMERCIAL GROWTH WOULD TAKE PLACE IN THE NEAREST COMMERCIALLY ZONED AREA. THERE ARE SUFFICIENT INDUSTRIAL LANDS ZONED THROUGHOUT THE BASIN TO ACCOMMODATE PROJECTED GROWTH, BUT NOT NECESSARILY FOR EACH INDIVIDUAL MUNICIPALITY.

9 10 11 ALL RESIDUAL VACANT RESIDENTIAL, COMMERCIAL, AND INDUSTRIAL DEVELOPABLE LANDS WERE REVIEWED AND COMPARED WITH COMMERCIAL AND INDUSTRIAL SPACE REQUIREMENTS.

12 COMMERCIAL GROWTH WAS THEN REDISTRIBUTED TO ACCOMMODATE COMMUNITY AND NEIGHBORHOOD COMMERCIAL NEEDS. IT WAS ASSUMED THAT RESIDUAL DEVELOPABLE RESIDENTIAL AND INDUSTRIAL LANDS WOULD BE REZONED COMMERCIAL AS REQUIRED. INDUSTRIAL GROWTH WAS DISTRIBUTED FIRST TO THE PLANNED INDUSTRIAL PARKS. EXCESS GROWTH WAS THEN TRANSFERRED TO INDUSTRIAL PARKS IN THE NEIGHBORING COMMUNITIES. NO NEW LANDS WERE ZONED INDUSTRIAL.

CHESTER CREEK BASIN, PENNSYLVANIA

## METHODOLOGY FOR PROJECTIONS
## LIMITED GROWTH
## COMMERCIAL & INDUSTRIAL LAND USE

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

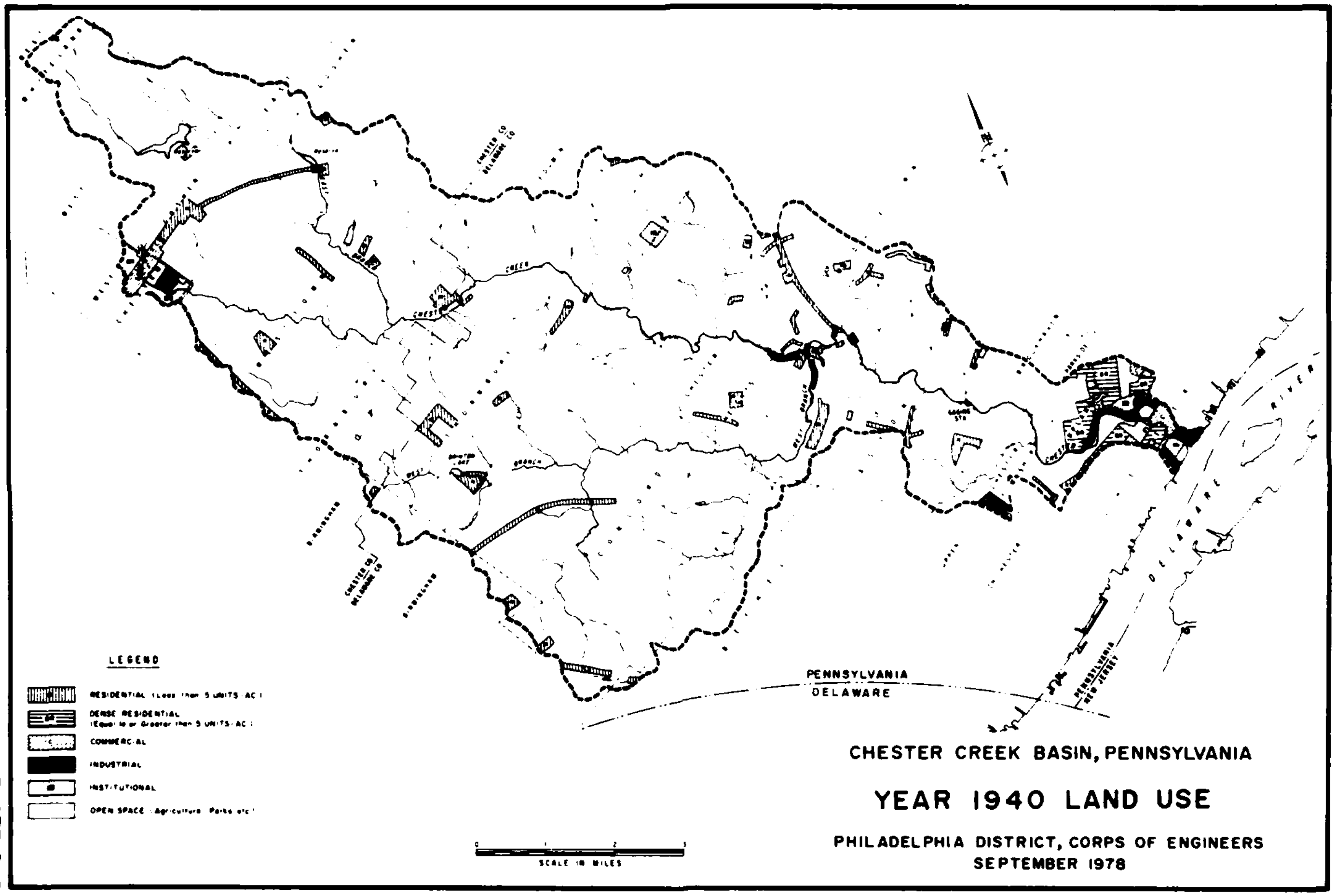

CHESTER CREEK BASIN, PENNSYLVANIA
YEAR 1940 LAND USE
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978
LEGEND
RESIDENTIAL (Less than 5 UNITS/AC)
DENSE RESIDENTIAL (Equal to or Greater than 5 UNITS/AC)
COMMERCIAL
INDUSTRIAL
INSTITUTIONAL
OPEN SPACE (Agriculture, Parks etc)
SCALE IN MILES
PENNSYLVANIA
DELAWARE
DELAWARE RIVER
PENNSYLVANIA
NEW JERSEY
CHESTER CO
DELAWARE CO

PLATE G-8

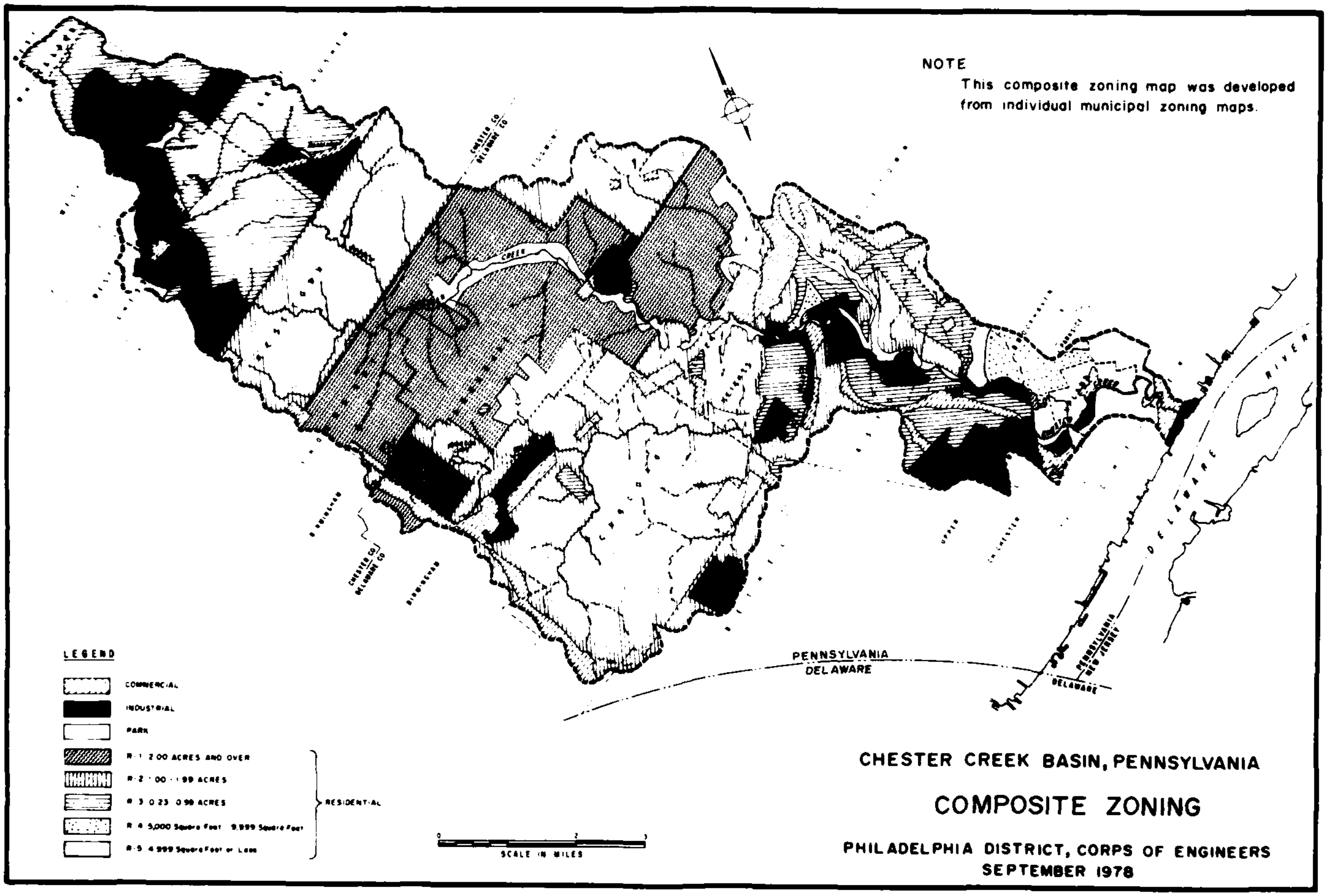

NOTE
This composite zoning map was developed from individual municipal zoning maps.
CHESTER CO.
DELAWARE CO.
CREEK
PENNSYLVANIA
DELAWARE
RIVER
LEGEND
COMMERCIAL
INDUSTRIAL
PARK
R-1 2.00 ACRES AND OVER
R-2 1.00 - 1.99 ACRES
R-3 0.23 - 0.99 ACRES
R-4 5,000 Square Feet - 9,999 Square Feet
R-5 4,999 Square Feet or Less
RESIDENTIAL
0
2
3
SCALE IN MILES
CHESTER CREEK BASIN, PENNSYLVANIA
COMPOSITE ZONING
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE G-9

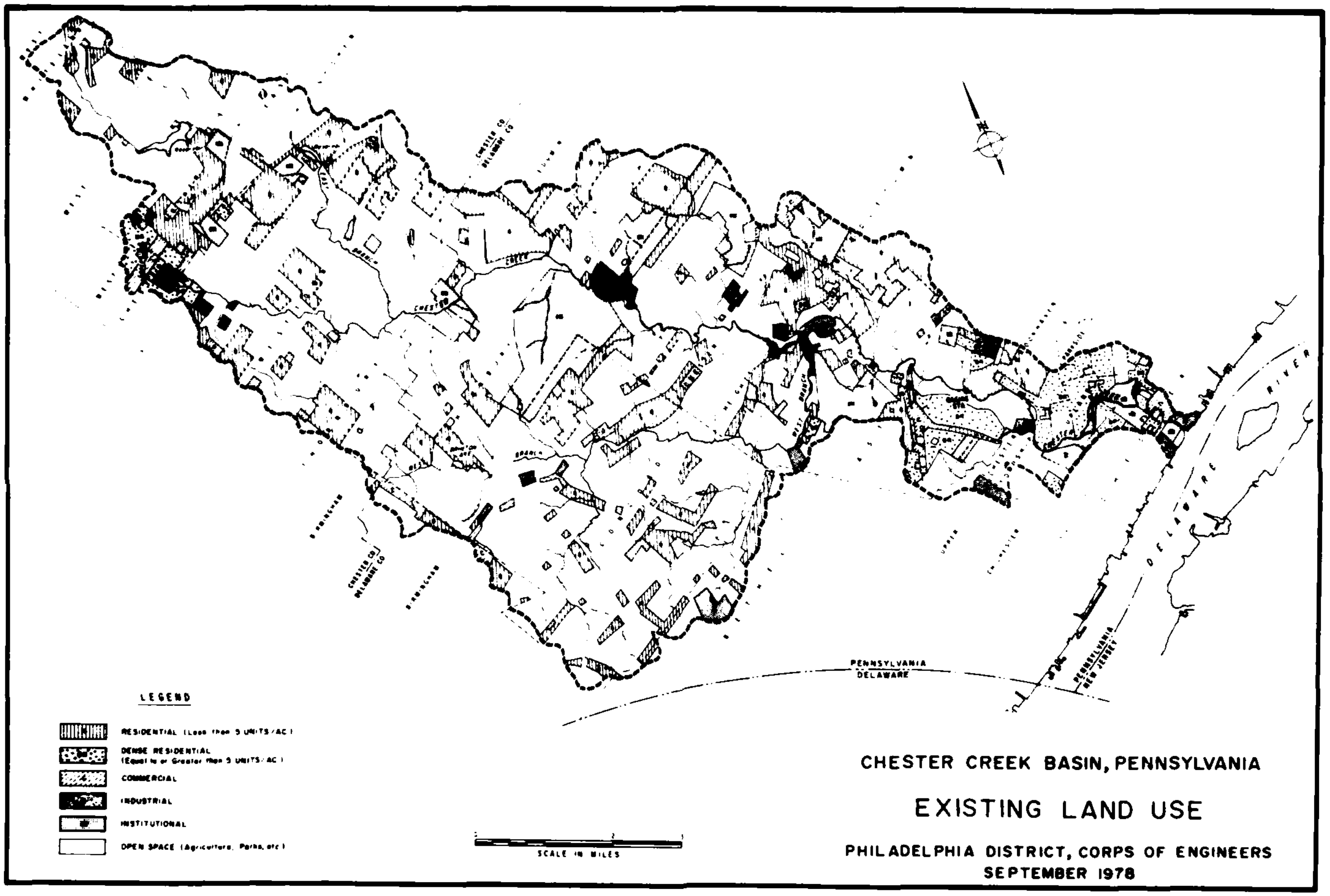
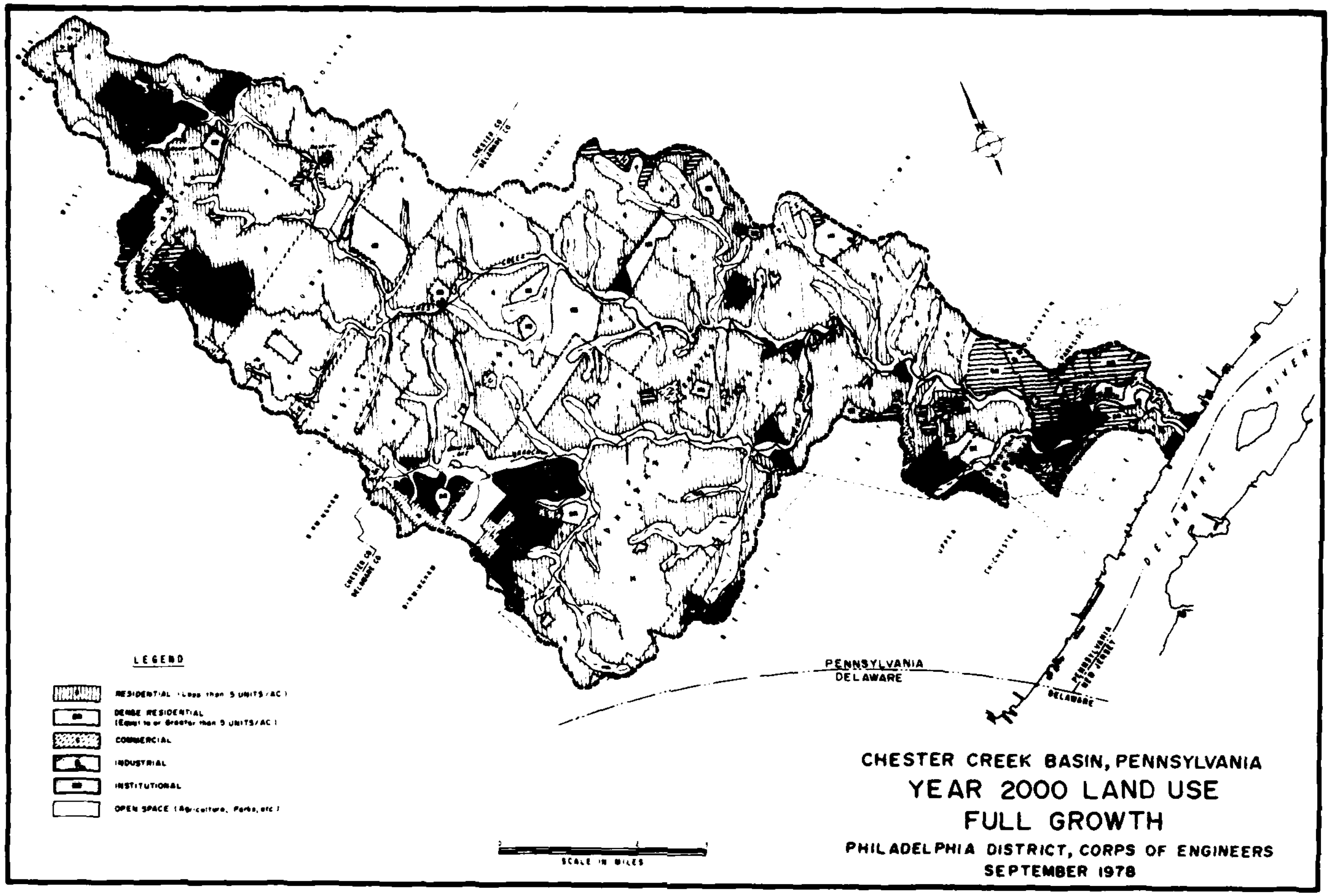

LEGEND
RESIDENTIAL (Less than 5 UNITS/AC)
DENSE RESIDENTIAL (Equal to or Greater than 5 UNITS/AC)
COMMERCIAL
INDUSTRIAL
INSTITUTIONAL
OPEN SPACE (Agriculture, Parks, etc)
SCALE IN MILES
PENNSYLVANIA
DELAWARE
DELAWARE
RIVER
CHESTER CREEK BASIN, PENNSYLVANIA
EXISTING LAND USE
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978

PLATE G-10



LEGEND
RESIDENTIAL (Less than 5 UNITS/AC)
DENSE RESIDENTIAL (Equal to or Greater than 5 UNITS/AC)
COMMERCIAL
INDUSTRIAL
INSTITUTIONAL
OPEN SPACE (Agriculture, Parks, etc.)
SCALE IN MILES
PENNSYLVANIA
DELAWARE
DELAWARE RIVER
CHESTER CREEK BASIN, PENNSYLVANIA
YEAR 2000 LAND USE
FULL GROWTH
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978


PLATE G-11

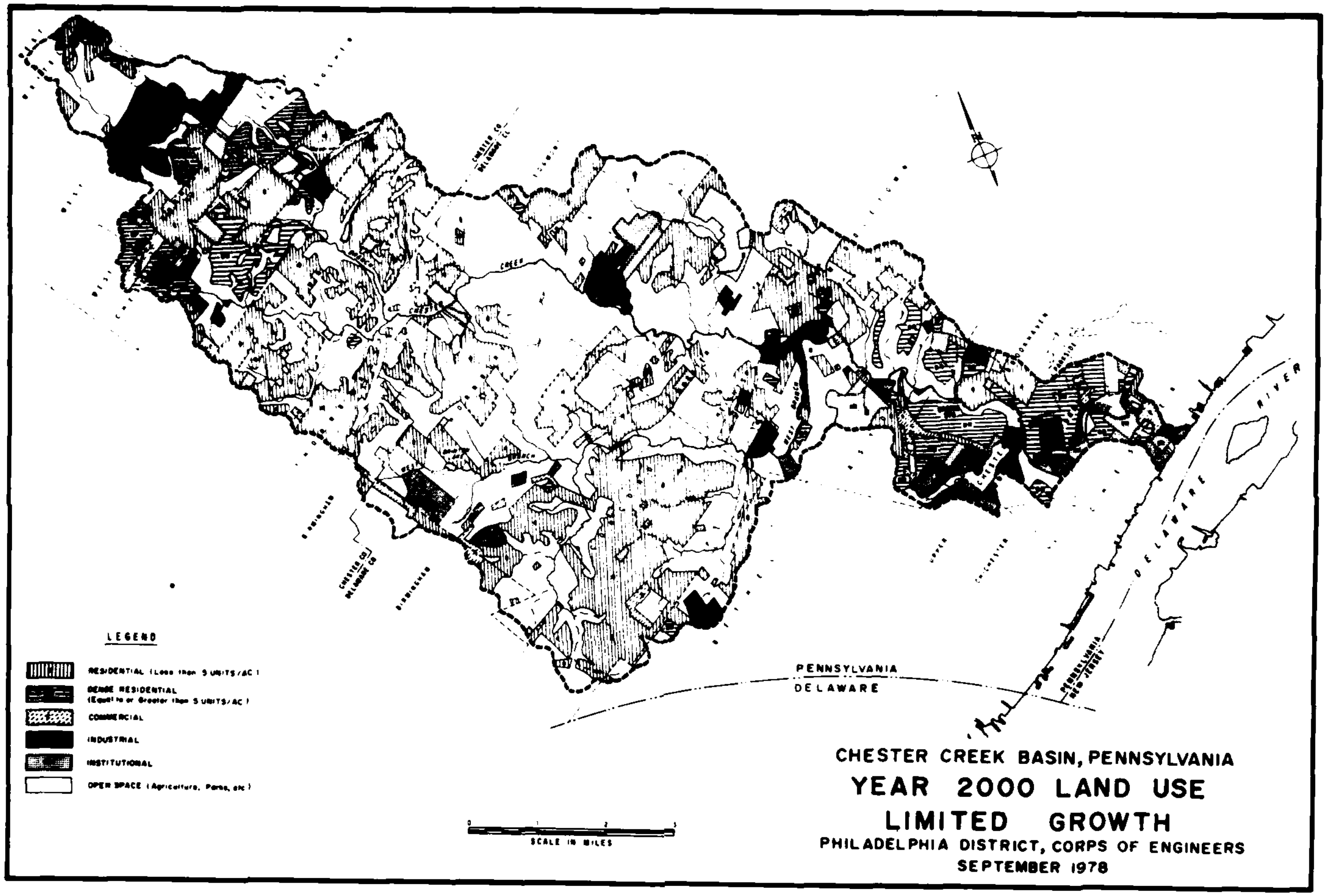
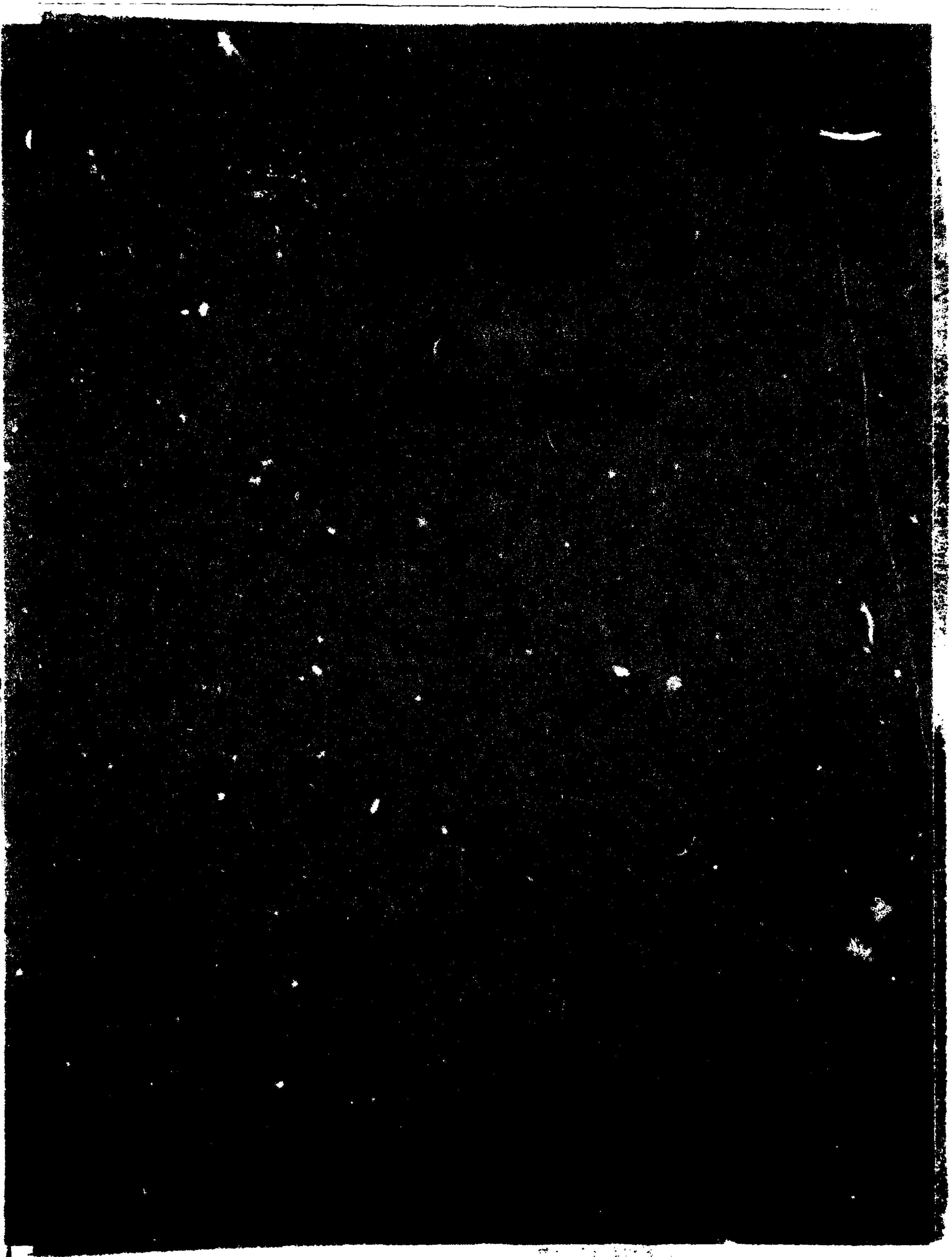
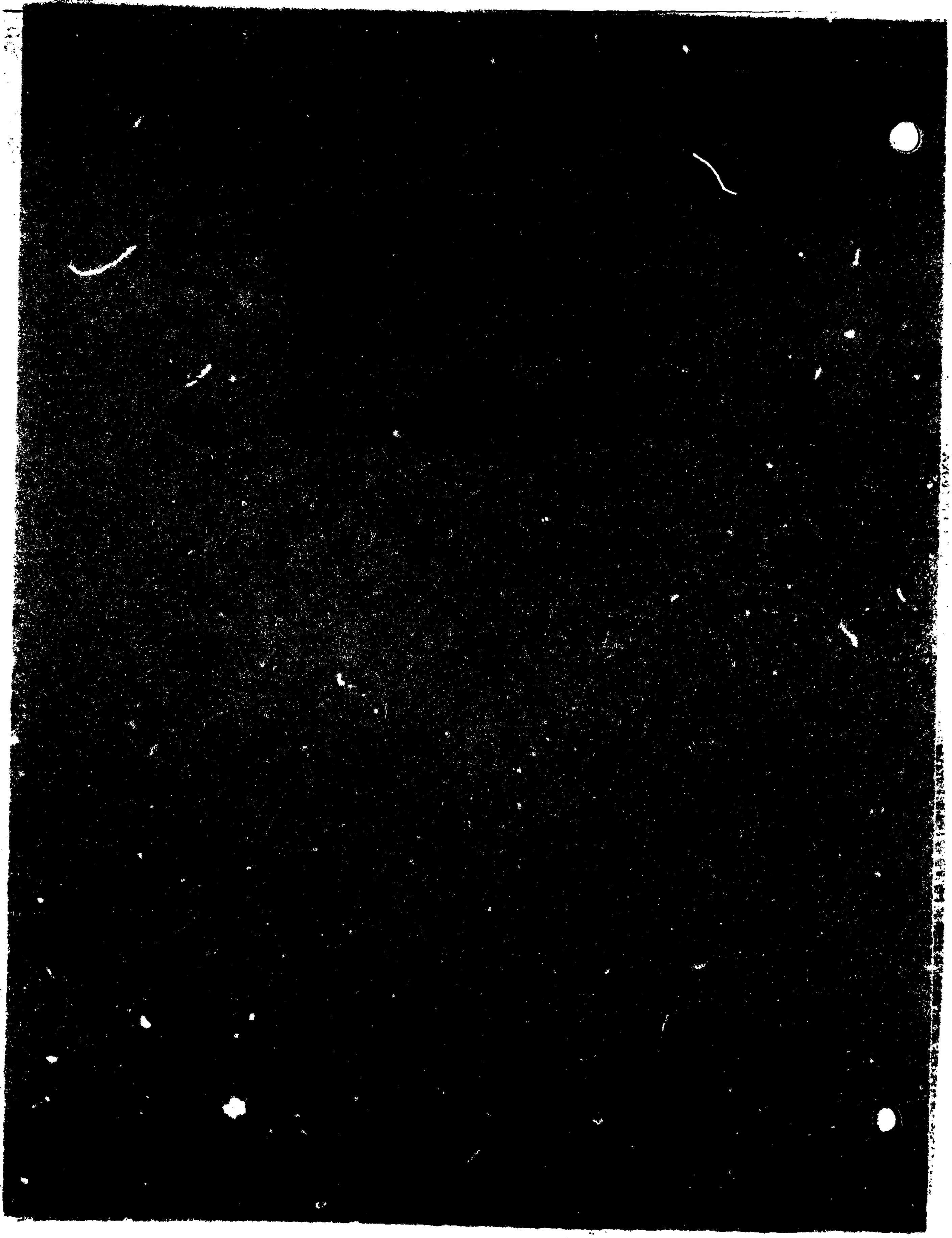

CHESTER CREEK BASIN, PENNSYLVANIA
YEAR 2000 LAND USE
LIMITED GROWTH
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SEPTEMBER 1978
LEGEND
RESIDENTIAL (Less than 5 UNITS/AC)
DENSE RESIDENTIAL (Equal to or Greater than 5 UNITS/AC)
COMMERCIAL
INDUSTRIAL
INSTITUTIONAL
OPEN SPACE (Agriculture, Parks, etc)
SCALE IN MILES
PENNSYLVANIA
DELAWARE
DELAWARE RIVER

PLATE G-12





SECTION H

# BENEFIT ANALYSIS

1. Benefit studies were conducted to evaluate the monetary value of existing and future benefits estimated to accrue as a result of implementing flood plain management plans in the Chester Creek Basin. The descriptions of the types of benefits considered, the methodologies, procedures, basic criteria, tools used and results achieved are presented here. The benefits of individual flood plain management plans are presented in Section D, Formulating a Plan.

## TYPES OF BENEFITS CONSIDERED

2. Consideration was given to solving other water resources problems. In addition to flood control. These included: water supply, recreation, commercial and recreational navigation, hydroelectric power, and hurricane and tidal flooding. Following preliminary analysis it was concluded that solutions to most of these problems could not be incorporated into flood control plans. A brief description of the findings are shown below.

3. There are water supply problems in the Basin. Water supply yields at reservoir sites or benefits were not calculated, since preliminary studies showed that storage capacities at the reservoirs site were not very large. Providing for water supply would either reduce the amount of storage available for flood control, or require an extensive amount of additional land. The reservoirs can not provide satisfactory levels of protection downstream the maximum capacity being a 50-year flood. Due to developments around reservoir sites the cost of additional lands was prohibitive, and would obviously not be justified. Water supply was eliminated due to high costs and to keep the effects of the reservoir on reducing flood damages at a maximum.

4. Inclusion of hydroelectric power at the reservoirs was also difficult to accomplish. Low stream flows, limited storage capacities, high costs for additional storage, and the higher priority needs for flood control caused hydroelectric power to be eliminated from consideration.

5. No commercial shipping has been reported to take place on the Chester Creek, and the need for commercial shipping was not expressed during the study. The absence of shipping is due to the relatively shallow depth of the Chester and many fixed bridges which would restrict useage. There is an inactive Federal project from the Delaware River to just below Second Street, a distance of 950 feet. There is a swing type railroad bridge about 500 feet from the Delaware River which has a clearance at mean high water of about one foot. The Second Street Bridge has a clearance of about six feet.

6. Tidal flooding is not a serious problem along the Chester Creek. The vast majority of damages result from fluvial or Chester Creek flooding. Tidal effects on fluvial flooding is limited to the lower reaches of the Creek in the City of Chester. Hurricane and tidal flood reduction benefits would normally be considered in the evaluation of certain types of flood control projects (i.e. levees, floodwalls or tidal dams). However, based on a preliminary benefit and cost analysis these types of projects could not be justified in the lower reaches of the Creek. They were not justified by such a wide margin that it was obvious that if tidal benefits were added they would still not be justified. Hurricane and tidal benefits were, therefore, not calculated.

7. Recreational navigation was not considered for most plans, since there is very little recreational boating on the Creek. The many low bridges, many bends, and urban development make recreational boating unattractive, and hazardous. Recreational boating at the reservoirs was not possible since dry reservoirs were needed. Flood plain evacuation plans in the lower reaches of the Creek did consider boating ramps as part of a overall recreation plan for the evacuated area. The City of Chester has also considered inclusion of recreational boating (ramps) in its long range planning for areas adjacent to the Creek near the Delaware River.

## TYPES OF BENEFITS EVALUATED

8. When something good occurs from an action, a benefit results. Damages, losses and other costs caused by floods are classified as tangible or intangible. Tangible costs are monetary values of physical damages to structures, both inside and outside, contents and other flood related costs. These flood related costs include expenditures for flood fighting, rescue work, emergency measures and preventive maintenance; losses to business, production, profits and wages; and other normal activities in the flooded area. Intangible costs are not assigned monetary values. Such costs included loss and/or damages to human life, safety and welfare. These costs would include human life, lack of adequate emergency facilities; unsanitary conditions caused by inoperable sewerage systems; spillages of raw sewerage and rats; and interruption of water supply. Intangible costs also include distruction of natural and beneficial flood plain values, aesthetic degradation, and community upheaval. When

any or all of these damages can be reduced or eliminated by implementing a flood control measure, benefits are produced. Similarly when other problems can be solved, or desirable activities can be included in the flood control project, other types of benefits result. This latter type of benefit would include the recreational benefits evaluated in this study.

9. Several types of flood control benefits were considered. Existing inundation reduction benefits to residential, commercial, industrial and public buildings, and contents; and, highways, utilities and emergency costs were evaluated. Future inundation reduction benefits (affluence) to residential contents were also evaluated. Increases in inundation damages to commercial, industrial, public, highway, utilities, or emergency cost were not projected to occur. Intensification and location benefits were also considered. The effects of increased development (urbanization) on flood damages was likewise evaluated.

For certain plans consideration was also given to benefits resulting from employment of unemployed or underemployed workers, advance replacement of bridges, and recreation.

## FLOOD CONTROL

10. INUNDATION REDUCTION. Flood control projects can make several types of beneficial contributions to the economic development of the nation. The more obvious contribution is the reduction or elimination of damages and associated costs for those activities which would use the flood plain without any flood control plans. These inundation reduction benefits consist of benefits to both existing and future uses. Existing average annual damages are estimated to be $720,330 in January 1978 dollars and for 1977 development conditions.

11. RESIDENTIAL. Residential damages accounted for about 24 percent of total damages which occurred during the September 1971 flood. No additional residential units are expected to be constructed in the flood plain unless residences are built above the 100-year flood elevation. This follows National Flood Insurance Program requirements. Pertinent data on existing residential development in the flood plain are listed below.

FLOOD PLAIN RESIDENTIAL PROPERTIES

| Items | Amount (1977 Conditions) |
|---|---|
| Number of Structures | 907 |
| Value of Structures & Contents | $18,100 to $104,000 |
| Value of Structure | $12,900 to $74,300 |
| Value of Contents | $5,200 to $29,700 |
| Average Value of Contents as a Percent of Average Structure Value | 40% |
| Percent of Total Residential Damage: | |
| To Contents | 40% |
| To Structure | 60% |
| Percent of Residential Damages to Total Damages | 31% |

12. During the 1971 flood, 732 homes were damaged. Since that time many of these residences have either been abandoned or demolished and removed. Most of the relocation of people has been the direct result of the flood problems. An example is the Eyre Park section of the City of Chester. All 216 homes have been demolished and removed. Presently the number of residences located in the 100-year flood plain is 758. An additional 149 homes are located between the 100-year and SPF flood limits. The total number of homes subject to flooding is 907.

13. Since there is no expected increase in the number of residential structures in the flood plain, future growth in damages is confined to increased value of residential contents. This type of growth is termed "affluence". Affluence is the effect of increasing per capita income on the real value of residential contents. A 2.46 percent per year increase in per capita income is appropriate for this study. The following data shows the per capita income projections for the OBERS Water Resources Subarea 0204 - Delaware. After comparison with other OBERS projections, including smaller areas it was determined that Subarea 0204 best represented the study area. Using the data below the growth rate for the sub-area would be 2.65%. This was reduced because portions of some of the reaches were considered to have less affluence growth than the Basin as a whole.

| Year | Amount (1967 Price Level)* |
|---|---|
| 1970 | $ 3,706 |
| 1980 | 5,000 |
| 1985 | 5,700 |
| 1990 | 6,400 |
| 2000 | 8,500 |
| 2020 | 13,700 |

14. The value of residential contents was increased at the per capita income growth rate to the maximum of 75 percent of the value of the residential structure of the first 50 years of project life, whichever comes first. For this study the 75 percent limit applied. In many reaches the growth in the value of residential contents could not be justified because of the general declining value and condition of many of the structures. Future growth for affluence was projected to occur in 12 of the 66 damage sub-reaches in the Basin. These reaches are 8A, 8B, 9B, 9D, 10B, 10C, 11E, 14, 17B, 51A, 51B, and 52B. In many of the remaining 44 sub-reaches the value of residential contents is already greater than 75 percent of the structure. For these other areas it was made reasonable to assume that increases in per capita income would be put to other uses rather than increasing the value of contents. Residents would probably invest this increased income in moving to other areas.

* Based on 1972 OBERS Projections of Regional Economic Activity in the U.S. (Volume 3, Water Resources Regions and Subareas).

15. Existing damages (1977 conditions) to residential contents are grown to the 1985 base year and then for two additional decades, to 2005 by applying the growth rate due to affluence. Contents damages grow from the existing $76,520 to $147,500 in 2005, a 93 percent increase. Affluence damages will remain constant after 2005. Table H-1 shows the affects of affluence on residential contents damages.

16. COMMERCIAL, INDUSTRIAL, AND PUBLIC. Commercial and industrial damages (includes damages to public buildings) accounted for about 67% of the damages resulting from the September 1971 flood. Presently there are over 140 commercial, industrial or public facilities in the flood plain. Existing average annual damages amount to $443,580. This is about 60 percent of total existing annual damages in the Basin. About $302,440 or 70 percent of these damages occur to contents with the remaining $131,141 or 30 percent being structural damages. No additional commercial or industrial development is expected to occur in the flood plain unless the buildings are built above the 100-year flood elevation or are flood proofed to that elevation. Future inundation damages therefore, would not occur. None have been estimated.

17. OTHERS. This category of damages includes damages to utilities and highways as well as flood emergency costs. All are structural damages. About 9 percent of the damages caused by the September 1971 flood were in this category. About $66,720 or 9 percent of the total existing damages in the Basin are in this category. No future inundation reduction benefits are projected because of flood plain regulation and development practices which should eliminate future growth and damage.

18. INTENSIFICATION. Benefits arise when a flood control plan enables an existing activity to modify its operation because the reduction in potential flood damages makes it profitable to do so. This "Intensification Benefit" will occur when the increased output can be produced more efficiently under project conditions by intensified operation on the existing acreage as opposed to increasing production elsewhere or bringing new areas into production. The benefit is the increased net income to the activity and landowner comparing the current and previous methods of operation.

19. In an attempt to identify and quantify the potential for intensification benefits, discussions took place with local officials and economic development groups on planned development and re-development activities. Reviews of published plans were made, as well as trends for industrial and commercial investments in the area. Since plant and other capital investments have been declining, it was concluded that this trend will continue in the future. It was also concluded that decisions affecting operations are based on factors other than those relating to the flood potential. Future intensification of viable existing commercial and industrial facilities can be made in accordance with proper flood plain development practices. Plant operations could be maintained. New development could be compatible with existing facilities. As a result

TABLE H-1
EFFECTS ON AFFLUENCE ON
RESIDENTIAL CONTENT DAMAGES
CHESTER CREEK BASIN
(THOUSANDS OF DOLLARS) 1/ 2/

| Sub-reach Number | Damage Category | Existing Damages 1977 (Sty. Yr.) | 1985 (Base Yr.) | Projected Total Future Damages 1995 | 2005 | 2015 | 2025 | 2035 | 2085 |
|---|---|---|---|---|---|---|---|---|---|
| 8A | w/o affl. | 14.92 | 14.92 | 14.92 | 14.92 | 14.92 | 14.92 | 14.92 | 14.92 |
| | affl. | 0. | 2.77 | 7.63 | 13.84 | 13.84 | 13.84 | 13.84 | 13.84 |
| | w/ affl. | 14.92 | 17.69 | 22.55 | 28.76 | 28.76 | 28.76 | 28.76 | 28.76 |
| 8B | w/o affl. | .03 | .03 | .03 | .03 | .03 | .03 | .03 | .03 |
| | affl. | 0. | .01 | .02 | .03 | .03 | .03 | .03 | .03 |
| | w/ affl. | .03 | .04 | .05 | .06 | .06 | .06 | .06 | .06 |
| 9B | w/o affl. | 11.74 | 11.74 | 11.74 | 11.74 | 11.74 | 11.74 | 11.74 | 11.74 |
| | affl. | 0. | 2.18 | 6.01 | 10.89 | 10.89 | 10.89 | 10.89 | 10.89 |
| | w/ affl. | 11.74 | 13.92 | 17.75 | 22.63 | 22.63 | 22.63 | 22.63 | 22.63 |
| 9D | w/o affl. | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 | 1.42 |
| | affl. | 0. | 0.26 | 0.73 | 1.32 | 1.32 | 1.32 | 1.32 | 1.32 |
| | w/ affl. | 1.42 | 1.68 | 2.15 | 2.74 | 2.74 | 2.74 | 2.74 | 2.74 |
| 10B | w/o affl. | 32.88 | 32.88 | 32.88 | 32.88 | 32.88 | 32.88 | 32.88 | 32.88 |
| | affl. | 0. | 6.10 | 16.82 | 30.49 | 30.49 | 30.49 | 30.49 | 30.49 |
| | w/ affl. | 32.88 | 38.98 | 49.70 | 63.37 | 63.37 | 63.37 | 63.37 | 63.37 |
| 10C | w/o affl. | 10.31 | 10.31 | 10.31 | 10.31 | 10.31 | 10.31 | 10.31 | 10.31 |
| | affl. | 0. | 1.91 | 5.27 | 9.56 | 9.56 | 9.56 | 9.56 | 9.56 |
| | w/ affl. | 10.31 | 12.22 | 15.58 | 19.87 | 19.87 | 19.87 | 19.87 | 19.87 |
| 11E | w/o affl. | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 | 1.70 |
| | affl. | 0. | 0.32 | 0.87 | 1.58 | 1.58 | 1.58 | 1.58 | 1.58 |
| | w/ affl. | 1.70 | 2.02 | 2.57 | 3.28 | 3.28 | 3.28 | 3.28 | 3.28 |
| 14 | w/o affl. | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 |
| | affl. | 0. | 0.04 | 0.10 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| | w/ affl. | 0.19 | 0.23 | 0.29 | 0.37 | 0.37 | 0.37 | 0.37 | 0.37 |
| 17B | w/o affl. | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 | 1.85 |
| | affl. | 0. | 0.34 | 0.77 | 1.72 | 1.72 | 1.72 | 1.72 | 1.72 |
| | w/ affl. | 1.85 | 2.19 | 2.62 | 3.57 | 3.57 | 3.57 | 3.57 | 3.57 |
| SUB-TOTAL 1A-18F | w/o affl. | 75.04 | 75.04 | 75.04 | 75.04 | 75.04 | 75.04 | 75.04 | 75.04 |
| | affl. | 0 | 13.93 | 38.22 | 69.61 | 69.61 | 69.61 | 69.61 | 69.61 |
| | w/ affl. | 75.04 | 88.97 | 113.26 | 144.65 | 144.65 | 144.65 | 144.65 | 144.65 |
| 51A | w/o affl. | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 |
| | affl. | 0. | 0.02 | 0.07 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |
| | w/ affl. | 0.13 | 0.15 | 0.20 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| 51B | w/o affl. | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 |
| | affl. | 0. | 0.13 | 0.35 | 0.64 | 0.64 | 0.64 | 0.64 | 0.64 |
| | w/ affl. | 0.69 | 0.82 | 1.04 | 1.33 | 1.33 | 1.33 | 1.33 | 1.33 |
| 52B | w/o affl. | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 |
| | affl. | 0. | 0.13 | 0.34 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 |
| | w/ affl. | 0.66 | 0.79 | 1.00 | 1.27 | 1.27 | 1.27 | 1.27 | 1.27 |
| SUB-TOTAL 51A-55 | w/o affl. | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 |
| | affl. | 0 | 0.28 | 0.76 | 1.37 | 1.37 | 1.37 | 1.37 | 1.37 |
| | w/ affl. | 1.48 | 1.76 | 2.24 | 2.85 | 2.85 | 2.85 | 2.85 | 2.85 |
| TOTAL 2/ | w/o affl. | 76.52 | 76.52 | 76.52 | 76.52 | 76.52 | 76.52 | 76.52 | 76.52 |
| | affl. | 0 | 14.21 | 38.98 | 70.98 | 70.98 | 70.98 | 70.98 | 70.98 |
| | w/ affl. | 76.52 | 90.73 | 115.50 | 147.50 | 147.50 | 147.50 | 147.50 | 147.50 |

1/ For selected reaches with existing land use and no future urbanization. All other reaches either had no residential damages or the residential content was considered to stabilize in the future: therefore, no affluence was assumed.
2/ All damages are undiscounted average annual damages in January 1978 dollars.

of these three conclusions, intensification benefits, if they occurred would be negligible from a national economic development standpoint. Accordingly, they have not been monetarily evaluated.

19. LOCATION. Benefits arise when a flood control plan makes flood plain land available for new use by reducing potential flood damages to activities which would not use the flood plain lands without projection. This "Location Benefit" only applies when a flood control plan makes land available for new uses which would not have been possible otherswise. The benefit is the difference in net income to the new activity comparing the flood plain site to the alternative off-flood plain site. Due to the large amounts of available and suitable alternative locations for development, it was concluded that there was no major advantage of using flood plain lands for commercial and industrial purposes. No location benefits would be expected to occur from implementation of a plan.

20. URBANIZATION. Increased urbanization will occur in non-flood plain Basin lands. Future developments will increase imperviousness which, in turn, increases stormwater runoff resulting in greater streamflows, shorter times of concentration, and higher flood stages. Within the flood plain, future land use was assumed to remain at the 1977 level of development because of the requirements of the Federal Disaster Protection Act of 1973 (Public Law 93-234). In order to be in compliance with this law, new development would have to be located either outside the 100-year flood plain, located at an elevation above the 100-year flood elevation, or flood proofed to the 100-year flood elevation. No increase in the 100-year heights over 1 foot would be allowed. Any construction which might take place in the flood plain would have little effect on increasing flood damages. For the purpose of analysis, it was assumed that no flood plain development would occur which would either increase stages or damages for the 100-year flood.

21. The most probable future was based on urbanization under a "limited growth" condition. A "full growth" condition was also considered. Limited growth assumes that more concentrated residential, commercial, and industry development; more strict adherence to slope and soil limitations; more demand for open space preservation; and more flexible municipal population growth by letting it cross municipal boundaries within the Basin. (A more detailed explanation is given in Section G, Urbanization Analysis).

22. The effects of this development on flood damages is significant. By 1985 there will be a 10 percent increase in flood damages. Due to urbanization only, by the year 2035 flood damages will increase by \$479,000, or a 66 percent increase over the existing damages of \$720,330.

23. SUMMARY. Table H-2 shows historic, study year, base year and future year damages. These damages are presented for existing, affluence, urbanization and the combination of urbanization on affluence. The

TABLE H-2
UNDISCOUNTED AVERAGE ANNUAL DAMAGES
FOR EXISTING/AFFLUENCE/URBANIZATION
1940 THROUGH 2085
(Thousands of Dollars) 1/

| Types of Damages | Sub-reaches | Historic Damages 1940 2/ | Existing Damages 1977 (Study Year) | Projected Total Future Damages 3/ 1985 (Base Year) | 1995 | 2005 | 2015 | 2025 | 2035 | 2085 |
|---|---|---|---|---|---|---|---|---|---|---|
| EXISTING (E) | 1A-18F | 560.91 | 586.43 | 586.43 | 586.43 | 586.43 | 586.43 | 586.43 | 586.43 | 586.43 |
| | 51A-55 | 133.90 | 133.90 | 133.90 | 133.90 | 133.90 | 133.90 | 133.90 | 133.90 | 133.90 |
| Subtotal | | 694.81 | 720.33 | 720.33 | 720.33 | 720.33 | 720.33 | 720.33 | 720.33 | 720.33 |
| % of Total | | 131% | 100% | 89% | 76% | 66% | 62% | 58% | 54% | 54% |
| AFFLUENCE (A) | 1A-18F | 0 | 0 | 13.93 | 38.22 | 69.61 | 69.61 | 69.61 | 69.61 | 69.61 |
| | 51A-55 | 0 | 0 | 0.28 | 0.76 | 1.37 | 1.37 | 1.37 | 1.37 | 1.37 |
| Subtotal | | 0 | 0 | 14.21 | 38.98 | 70.98 | 70.98 | 70.98 | 70.98 | 70.98 |
| % of Total | | 0% | 0% | 2% | 4% | 6% | 6% | 6% | 5% | 5% |
| URBANIZATION (U1) | 1A-18F | -132.62 | 0 | 72.41 | 165.62 | 256.67 | 315.98 | 379.07 | 474.07 | 474.07 |
| | 51A-55 | - 31.87 | 0 | 1.73 | 3.88 | 4.93 | 4.93 | 4.93 | 4.93 | 4.93 |
| Subtotal | | -164.87 | 0 | 74.14 | 169.50 | 261.60 | 320.91 | 384.00 | 479.00 | 479.00 |
| % of Total | | -31% | 0% | 9% | 18% | 24% | 28% | 31% | 36% | 36% |
| URBANIZATION ON AFFLUENCE (U2) | 1A-18F | 0 | 0 | 3.10 | 15.44 | 40.32 | 48.45 | 57.05 | 70.18 | 70.18 |
| | 51A-55 | 0 | 0 | 0.01 | 0.02 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| Subtotal | | 0 | 0 | 3.11 | 15.46 | 40.37 | 48.50 | 57.10 | 70.23 | 70.23 |
| % of Total | | 0% | 0% | 0% | 2% | 4% | 4% | 5% | 5% | 5% |
| TOTAL (E,A,U,U2) | | 529.92 | 720.33 | 811.79 | 944.27 | 1093.28 | 1160.72 | 1232.41 | 1340.54 | 1340.54 |

1/ All damages are in undiscounted average annual damages in January 1978 dollars.
2/ The 1940 damages reflect the existing level of flood plain development with 1940 hydrology.
3/ Average annual damages include existing damages with urbanization hydrology (limited growth future) and residential affluence.

values are undiscounted average annual damages. As can be seen, a large amount of future damages will occur due to continued development in upstream areas. In 2035, about 36 percent of flood damages or about $479,000 will be due to future development of upstream areas.

24. Table H-3 presents the future flood damages by property type and shows whether the damages are structural or content damages. These damages are also undiscounted average annual damages.

## ADVANCE BRIDGE REPLACEMENT

25. Benefits for advance bridge replacement were also considered. By replacing existing bridges a flood control plan would, in effect, extend the period the bridge would continue to function and thereby extend the bridge's benefits. This type of benefit is applicable to certain flood control plans and the amount varies with each plan. Further explanation of this benefit is given under "Methods of Analysis" in this section.

## NED EMPLOYMENT

26. Benefits resulting from payments to unemployed or underemployed construction workers directly employed in construction of a project were also considered. This benefit represents the amount of wages earned by workers who would be unemployed in the absence of a project. To be eligible for these benefits, the project's area must have been declared a Title IV redevelopment area by the Economic Development Administration. Delaware County has received this designation. The amount of this benefit varies with each plan. Further explanation of employment benefits is given under "Methods of Analysis" in this section.

## RECREATION

27. The Pennsylvania Department of Environmental Resources (DER) in the "State Water Plan" projects a considerable need for additional outdoor recreational facilities in Sub-Basin 3G, of which the Chester Creek Basin is a part. There will be a need for 2,190 additional picnic tables by 1990 and 2,780 tables by 2020. There will be a need for 1534 additional acres of water for power boats by 1990 and 2389 acres by 2020. Fishing man-days and beach footage also will be in short supply in both 1990 and 2020. The 1968 Open Space Report by the Citizens Council of Delaware County concluded that with a minimum of 10 acres of open space per 1000 persons. Delaware County lacks 11,400 acres to meet these standards in 1970. Based on the 1970 Survey of Outdoor Recreation Activities, the

TABLE H-3
UNDISCOUNTED AVERAGE ANNUAL DAMAGES
BY CATEGORIES AND TYPES
1940 THROUGH 2085
(Thousands of Dollars) 1/

| Property Types | Sub-reaches | Historic Damages 1940 2/ | Existing Damages 1977 (Study Year) | Projected Total Future Damages 3/ 1985 (Base Year) | 1995 | 2005 | 2015 | 2025 | 2035 | 2085 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Residential** | | | | | | | | | | |
| Contents | 1A-18F | 60.99 | 81.40 | 108.81 | 158.88 | 228.45 | 245.34 | 263.22 | 290.51 | 290.51 |
| | 51A-55 | 5.44 | 7.10 | 7.48 | 8.59 | 9.68 | 9.68 | 9.68 | 9.68 | 9.68 |
| Subtotal | | 66.43 | 88.50 | 116.29 | 167.47 | 238.13 | 255.02 | 272.90 | 300.19 | 300.19 |
| Structural | 1A-18F | 81.40 | 107.16 | 120.34 | 137.77 | 155.30 | 166.93 | 179.37 | 198.18 | 198.18 |
| | 51A-55 | 18.73 | 24.37 | 24.74 | 24.94 | 25.10 | 25.10 | 25.10 | 25.10 | 25.10 |
| Subtotal | | 100.13 | 131.53 | 145.08 | 162.71 | 180.40 | 192.03 | 204.47 | 223.28 | 223.28 |
| Subtotal-Residential | | 166.56 | 220.03 | 261.37 | 330.18 | 418.53 | 447.05 | 447.37 | 523.47 | 523.47 |
| **Commercial & Industrial** | | | | | | | | | | |
| Contents | 1A-18F | 170.55 | 230.54 | 260.51 | 298.82 | 335.80 | 359.70 | 385.30 | 423.34 | 423.34 |
| | 51A-55 | 54.92 | 71.90 | 72.71 | 73.71 | 74.05 | 74.05 | 74.05 | 74.05 | 74.05 |
| Subtotal | | 225.47 | 302.44 | 333.22 | 372.53 | 409.85 | 433.75 | 459.35 | 497.39 | 497.39 |
| Structure | 1A-18F | 75.35 | 100.61 | 113.41 | 129.75 | 145.43 | 155.62 | 166.30 | 182.70 | 182.70 |
| | 51A-55 | 22.54 | 30.53 | 30.99 | 31.32 | 31.42 | 31.42 | 31.42 | 31.42 | 31.42 |
| Subtotal | | 97.89 | 131.14 | 144.40 | 161.07 | 176.85 | 187.04 | 197.72 | 214.12 | 214.12 |
| Subtotal-Commercial & Industrial | | 323.36 | 433.58 | 477.62 | 533.60 | 586.70 | 620.79 | 657.07 | 711.51 | 711.51 |
| **Other** | | | | | | | | | | |
| Structure | 1A-18F | 40.00 | 66.72 | 72.80 | 80.49 | 88.05 | 92.88 | 97.97 | 105.54 | 105.54 |
| | 51A-55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Subtotal-Other | | 40.00 | 66.72 | 72.80 | 80.49 | 88.05 | 92.88 | 97.97 | 105.54 | 105.54 |
| Subtotal | 1A-18F | 428.29 | 586.43 | 675.87 | 805.71 | 953.03 | 1020.47 | 1092.16 | 1200.27 | 1200.27 |
| | 51A-55 | 101.63 | 133.90 | 135.92 | 138.56 | 140.25 | 140.25 | 140.25 | 140.25 | 140.25 |
| TOTAL | | 529.92 | 720.33 | 811.79 | 944.27 | 1093.28 | 1160.72 | 1232.41 | 1340.54 | 1340.54 |

1/ All damages are in undiscounted average annual damages in January 1978 dollars.
2/ The 1940 damages reflect the existing level of flood plain development with 1940 hydrology.
3/ Average annual damages include existing damages with urbanization hydrology (limited growth future) and residential affluence.

Basin would have an estimated 2,500 bird and wildlife photographers, 3,800 bird watchers, and about 15,000 persons who take nature walks each year.

28. In 1975 the Delaware County Planning Commission (DCPC) conducted a study of open space, parks and recreation. One of the major findings was that there is a significant dificiency of public owned land for recreation. One of the major recommendations to come out of the study was to acquire public access and/or ownership of stream valleys and flood plains and provide bicycle trails and hiking paths in these areas. Another recommendation was to acquire additional large tracts of land as available (100-acre minimum) for major park areas. Based on DER and DCPC findings, it was assumed that any recreational or open space areas which could be provided as a part of a flood control plan would be fully utilized.

## ASSUMPTIONS AND CRITERIA

29. Special assumptions and criteria were established prior to conducting the benefit analyses. These were the basis for all calculations and are presented in the following paragraphs.

### FLOOD CONTROL

30. The basic assumptions and criteria for the flood control benefit analysis of this study are summarized below:

Study Year - 1977
Base Year - 1985
Period of Analysis - 50 Years (and 100 years for major projects)
Damage estimates - January 1978 dollars (updated July 1974 dollars)
Discount rates - 6-5/8, 8 and 10 percent (current applicable rate is 6-5/8%)
Affluent growth on residential contents - 2.46 percent per year
Future land use outside the flood plain - projected for years 1985, 1995, 2005, 2015, 2025, and 2035
Future land use inside the flood plain - 1977 land use.

31. Where applicable, the flood control criteria was used to calculate advance bridge replacement and NED employment benefits.

### RECREATION

32. Standards for various recreational activities were obtained from

several sources DER; the "Water Oriented Recreation Study of the Upper Delaware River Basin;" the U.S. Department of the Interior; and the National Recreation and Parks Association. The following standards have been selected for use in this study:

PICNICKING. DER recommended medium density development of all recreational facilities in Region 3. The standards for medium density are 15 tables per acre, 4.5 people per table, a turnover rate of 1.5 per day, 2.5 recreation-days per week, and 13 weeks per summer season. 79.2 percent of picnicking takes place during the summer season.

NON-POWER BOATING.* DER's standards for medium density are 1-1/3 boats per acre, 2 people per boat, a turnover rate of 2 per day, 2.5 recreation-days per week, and 13 weeks per summer season. 74.9 percent of boating takes place during the summer season.

UNLIMITED POWER BOATING. DER's standards for medium density are 1/3 boat per acre, 3.5 people per boat, a turnover rate of 2 per day, 2.5 recreation-days per week, and 13 weeks per summer season. 74.9 percent of boating takes place during the summer season. The Corps of Engineers standard for boat launchings is 40 per day per lane.

ICE SKATING.* Based on discussions held with DER, 1000 skaters per acre is a reasonable figure as is a turnover rate of 2 per day. We assume 2.5 recreation-days per week and 8 weeks per season.

HIKING. DER's standards for medium density are 17 people per mile of trail and a turnover rate of 5 per day. We assume there are 2.5 recreation-days per week and 13 weeks per summer season. 50 percent of the hiking takes place during the summer season.

BICYCLING. According to the National Recreation and Park Association, 50 cyclists per hour can be expected to use a bicycle lane during peak hours, cyclists travel at an average speed of 10 mph, and recreational cyclists average 10 miles per trip. We assume there are 2.5 recreation-days per week and 13 weeks per summer season. 50 percent of bicycling takes place during the summer season.

## METHOD OF ANALYSIS

33. All benefit computations were carried out using traditional economic

* These activities were initially considered at permanent pool reservoirs R6, R10, and R13. It was later decided that no permanent pools would be provided.

methodology. Computer programs were used whenever possible. Computer programs were used for most of the flood control benefit analyses. Recreation benefit computations were not computerized.

## FLOOD CONTROL

34. COLLECTION OF FLOOD DAMAGE DATA. On 11 September 1974 officials of Chester and Delaware Counties and 11 municipalities in the Basin attended a workshop meeting to discuss the conduct of the flood damage survey. They were given a presentation on the purpose of the damage survey, the type of information required, procedures to be followed, and problems which usually arise. Letters were sent to all appropriate public agencies, the 52 residential units that were expected to be sampled, and all 130 flood prone businesses (commercial and industrial) initially identified prior to the field damage survey. These letters were sent to prepare the persons to be interviewed, thereby reducing interview time, increasing the quality of information collected, and reducing the amount of followup effort.

35. A four week field damage survey was conducted during September and October 1974. The flood damage survey was an assessment of all flood damage and related costs in the Chester Creek flood plain. Through interviews and inspection, cost estimates were made for the repair and replacement of damageable assets, cleanup and business losses.

36. Over 750 residences were inventoried and 10 homes were selected for detailed analysis. A detailed inspection of the property and an indepth interview with the owner/resident of each of the 10 residences was conducted. Detailed interviews with officials of all municipalities and almost all of the commercial, industrial, and public units were also conducted. Where interviews were not possible, damages were estimated based on damage estimates for similar units for which interviews were conducted. Interviews were also conducted with officials of the companies and agencies responsible for railroads, utilities and highways in the Basin.

37. During the interviews inventories were made of damageable structural and content items for both the interior and exterior of the buildings. Information was obtained on historic damages and flood costs which resulted from the September 1971 flood. Historic data was used by updating and comparing it to the estimated flood stage-damage curves which were drawn for the contents and structure of each interviewed unit. Flood damages were estimated at differing stages of flooding both above and below the 1971 flood stage. This was done on an individual basis for all distinguishable or separable units such as residential, commercial, industrial, and public units.

38. Supplemental damage surveys were conducted in January 1976 in the lower reaches of Chester Creek and April 1976 in the Goose Creek area. These were conducted to complete the inventories of all damageable units up to the Standard Project Flood Plain limits. These surveys added 40 businesses and 158 residences to the stage-flood damage information obtained in 1974.

39. Additional modifications were made to the damage information in November 1977 to update conditions in the City of Chester by eliminating the damages for 15 businesses and 23 residences which had been or were planned to be demolished prior to the construction of any possible projects.

40. FLOOD DAMAGE ANALYSIS. Inundation reduction benefits include the reduction of physical flood losses to structures and their contents; reduction of business and financial losses; and reduction of emergency costs. Business and financial losses were included in the flood damages as commercial and industrial contents. Emergency costs were included in the "Other" category of damages. All flood costs were initially computed in July 1974 dollars and conditions prevailing in that year. All updates of price levels were conducted with appropriate escalation factors based on changes in the Consumer Price Index (CPI) and Building Cost Index (BCI). Flood damages were estimated at differing stages of flooding.

41. Ten residential interview samplings had been taken in the field. Relationships between the depth of flooding in the house and total flood damages were determined. Damages were computed separately for each structure and its contents. These were then related to the cost of the house without the building lot. All other residential properties in the flood prone areas were inventoried. Data inventoried included the elevation of the first floor relative to historic high-water (the 1971 flood); the zero damage elevation; and the type of structure. Stage damage relationships for the structure and contents were developed for each residential unit. These individual units results were then correlated and cumulated by each damage sub-reach and reach.

42. For each commercial, industrial, and public unit, individual stage-flood damage relationships were developed for both the structures and their contents. The individual stage-flood damage relationships were then correlated and cumulated for each sub-reach and reach.

43. For all other damage categories, estimates were based heavily on historic data which were analyzed in order to reconstruct when the damages or costs were first initiated, how they were physically incurred, and how they were distributed with depth of flooding. Estimates of increases beyond depths of flooding from the flood of record were then extended.

44. Traditional methods of computing annual damages by intergration of a damage-frequency relationship were employed. Stage-damage relationships

were developed from the damage survey information gathered for buildings up to the SPF flood plain. These relationships were used both individually and aggregated by sub-reach in analyzing the various flood control plans. Stage-discharge and discharge-frequency relationships were combined to compute damage-frequency relationships. The following tabulation contains representative data points from a stage-damage curve developed for sub-reaches 1A and 1B.

STAGE-DAMAGE DATA - SUB-REACHES 1A AND 1B
(January 1978 Price Level)

| Stage (Ft - MSLD) | Damages |
|---|---|
| 11.73 | $ 0 |
| 12.73 | 11,650 |
| 13.73 | 25,890 |
| 14.73 | 45,310 |
| 15.73 | 81,550 |
| 16.73 | 156,790 |
| 17.73 | 216,980 |
| 19.73 | 430,850 |
| 21.73 | 546,960 |

45. METHODS USED. In order to compute flood damages and inundation reduction benefits, both computer and hand calculations were used. Since the computer models were "state of the art" different programs were used as the study progressed. The calculation of damages and benefits included existing damages as well as future damages due to affluence growth on residential contents. The computer programs used for damage calculations also measured the increases in future flood damages resulting from hydrologic changes due to urbanization.

46. The first computer program used to calculate average annual damages in sub-reaches 1A-18F was developed by HEC*. It was used to screen alternative reservoir sites and for analysis of non-structural plans. At the beginning of the study, all analyses were made using the HEC program. However, in Stage II when more refined evaluation was desired a second program was used.

47. This second program was originally developed by the Los Angeles District (LA)** and was modified for use of this study. It was used to carry out a more refined analysis. The program calculated existing average annual damages, future urbanization damages, and growth in damages to residential contents. The program also computed equivalent average annual damages. The program was used for sub-reaches 1A through

* Program titled "Average Annual Damages," The Hydrologic Engineering Center, July 1973.
** Program Titled "Damages," U.S. Army Engineer District, Los Angeles, June 1971

18F. Only flood reduction benefits resulting from the more promising alternatives were refined and re-evaluated during Stage II using this program. Flood reduction benefits from reservoirs and local protection projects (levees and floodwalls) were evaluated using the modified LA program.

48. A comparison of the accuracy of both models was made. The HEC model can accept up to 20 points on a stage-damage curve. The LA model can accept only 10. The difference in computational results for these two methods are less than 10 percent for any given sub-reachs and less than 5 percent overall, based on the differences in number of data points inputted. Decisions made in preliminary evaluations to drop certain flood control plans because of the lack of economic justification were considered valid.

49. A third program was used during further studies to evaluate the benefits of plans S3A, S3Ab, and L6G as well as to update the stage-damage data to 1977 conditions for use in developing Tables H-1 to H-5. This program did not calculate the growth in residential inundations damages (affluence on residential contents). Therefore, hand calculations were made on the growth of existing content damages and the effects of urbanization on these damages. The effects of urbanization on existing damages were still modelled by the computer.

50. Since the Goose Creek drainage area, in the upper basin, was not modelled hydrologically or hydraulically by computers, and since the damage areas are relatively small, calculations of damages and benefits and the effects of affluence and urbanization were done by hand.

51. Each of the three programs developed a flood damage-frequency curve through use of stage-damage, stage-discharge, and discharge frequency curves.

52. INUNDATION REDUCTION BENEFIT ANALYSIS AND RESULTS. The existing average annual damages are $720,330. Of this amount $586,430 are estimated to occur in the lower Basin (sub-reaches 1A-18F) and $133,900 in the upper Basin (sub-reaches 51A-55). These values were then increased by adding the affluence on residential contents.

53. Affluence was calculated as a factor based on increases in per capita income, as previously described. The following calculations show the development of the factors used:

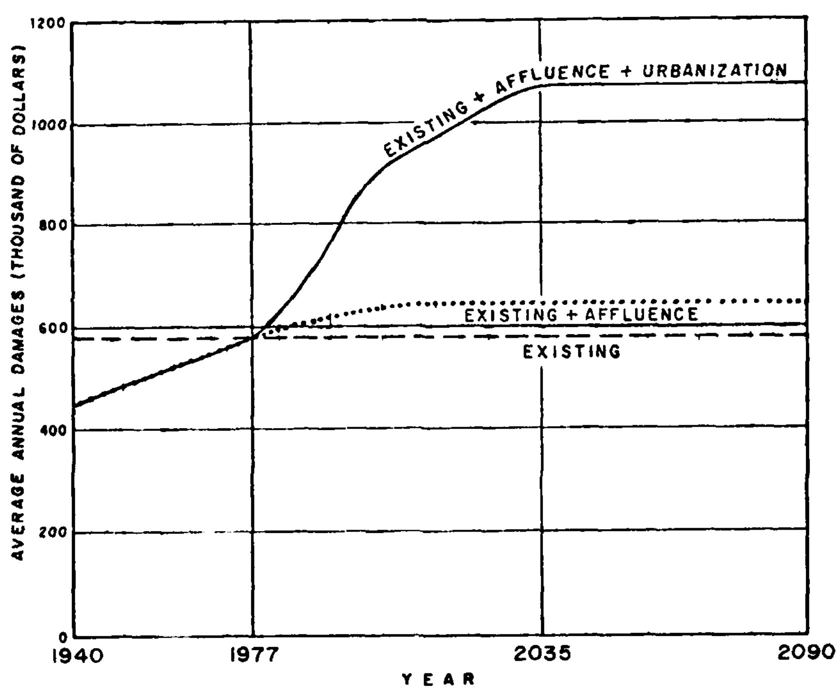
Growth Rate = 2.46%
Study Year = 1977
Base Year = 1985
Year Affluence Growth Ends = 2005
1985 Factor* = 1.0246**7 = 1.185442
1995 Factor = 1.0246**17= 1.511555
2005 to 2085 Factor = 1.0246**27 = 1.927381

* The analysis was completed in December 1977 with a project estimated to be operational in the beginning of 1985.

54. These factors are applied to residential contents to get undiscounted residential contents damage plus affluence for 1985 and the following two decades to 2005. No growth in residential contents was projected to take place for 2005 to 2035. The factor to calculate the effects of affluence on equivalent basis was calculated as (1.185442xAAD) + (1.185442 x AAD) x APWR (6-5/8%, 20 yrs) + (1.927381 - 1.185442) AAD (USPWF (6-5/8% 30 yrs)) x (SPPWF (6-5/8%, 20 yrs)) x CRF 6-5/8%, 50 yrs. which equals 1.581516. Residential contents to which affluence was applied increased to $147,500 in 2005 from $90,730 in the base year (1985) as shown in Table H-1.

55. Increases in average annual damages due to non-flood plain urbanization are comprised of not only existing average annual damages but also residential contents damages due to affluence. Table H-2 shows these growths in undiscounted average annual damages by decade. Past (1940) and current (1977) information is also presented. Urbanization effects on existing damages and affluence are shown to increased by 471,980 from 1985 to 2035. These were calculated by computer for sub-reaches 1A to 18F and by hand for sub-reaches 51A to 55. The estimates for 1940 and 1977 represent November 1977 level of development in the flood plain. All growth and increased stormwater runoff is predicted to occur by the year 2035.

56. The following figure shows the existing average annual damages and the the effects of urbanization and affluence for the period 1940 to 2090. Damage values projected beyond the study year are undiscounted average annual damages.



57. When the damages during the period of analysis are expressed on an equivalent annual basis, the existing average annual damages of $720,330 increased to $987,800 annually. This increase is comprised of urbanization of existing damages and affluence ($208,720) and the effects of affluence on residential contents ($58,750). About 85% of the equivalent average annual damages are expected to occur in the lower Basin (sub-reach 1A-18F) and 15 percent in the upper Basin (sub-reaches 51A-55).

58. Table H-4 also presents the equivalent average annual damages by flood plain zone (i.e.: 0 to 4%, 4% to 2%, 2% to 1% and 1% to SPF).

59. By comparing the with and without project conditions, benefits are obtained as the difference between these two conditions expressed on equivalent annual basis.

60. At the initiation of the formulation of alternative plans, an analysis of potential benefits for differing levels of protection (50 and 100-year) was conducted for each sub-reach in the lower and upper Basin. This was used to screen initial project or program potential so as to eliminate all obviously economically impractical concepts. The results are presented in Table H-5. It became obvious that local flood protection projects would not be economically justified for many sub-reaches.

## ADVANCE REPLACEMENT OF BRIDGES

61. Several of the plans involved replacement of bridges across the Chester Creek. Since the replacement of these bridges, as a project cost, is actually extending the period during which the bridge's existing benefits will be realized, an adjustment is necessary to credit the project with the resulting extension in benefits. This credit is considered as a benefit.

62. Plans S3A, S3Ab and L6G extend the lives of the Fifth, Sixth, and Seventh Street bridges in the City of Chester. Plans S3A and S3Ab include the Ninth Street bridge. Based on an assumption of 1985 as the base year, when the project is first operational, the lives of the Fifth and Seventh Street Bridges would be extended by 18 years. The Sixth Street Bridge would have its life expectancy increased by about 21 years. Replacement of Ninth Street Bridge by a project would extend its life by 33 years. The annual benefits attributable to the existing bridges are assumed to equal or exceed the annual costs of construction for new spans of equal length. These costs differ from the replacement costs as components of flood control plans since span lengths were increased to increase flow capacities under the bridges. The benefits for replacement of the four bridges are calculated as follows:

TABLE H-[illegible]
EQUIVALENT AVERAGE ANNUAL DAMAGES FOR
DIFFERENT ANALYSIS PERIODS AND INTEREST RATES
(Thousands of Dollars) 1/

| Frequencies of Events 2/ | 50-Year Life 6-5/8% | 50-Year Life 8% | 50-Year Life 10% | 100-Year Life 6-5/8% | 100-Year Life 8% | 100-Year Life 10% |
|---|---|---|---|---|---|---|
| 0-25 | 423.39 | 416.07 | 407.81 | 431.92 | 420.54 | 409.69 |
| Cumulative | 423.39 | 416.07 | 407.81 | 431.92 | 420.54 | 409.69 |
| 25-50 | 149.53 | 146.53 | 143.63 | 152.13 | 148.11 | 144.29 |
| Cumulative | 572.92 | 562.60 | 551.44 | 584.05 | 568.65 | 553.98 |
| 50-100 | 148.17 | 142.53 | 139.70 | 146.67 | 143.49 | 140.12 |
| Cumulative | 721.09 | 705.13 | 691.14 | 730.72 | 712.14 | 694.10 |
| 100-SPF | 266.71 | 265.64 | 260.36 | 270.80 | 266.34 | 260.69 |
| Cumulative | 987.80 | 970.77 | 951.50 | 1001.52 | 978.48 | 954.79 |

1/ Equivalent average annual damages include existing damages with urbanization hydrology (limited growth future) and affluence to residential contents. January 1978 dollars.
2/ Frequencies refer to hydrology at the USGS gage at Dutton Mill Road.

TABLE H-5
DISTRIBUTION OF
EQUIVALENT AVERAGE ANNUAL DAMAGES
BY REACH AND BY FREQUENCIES
(Thousands Dollars) 1/

| Sub-reach Number | Total 2/ EAAD | EAAD 3/ 100-Yr. Resid. (% of Total) | EAAD 4/ 100-Yr. Benef. (% of Total) | EAAD 3/ 150-Yr. Resid. (% of Total) | EAAD 4/ 150-Yr. Benef. (% of Total) |
|---|---|---|---|---|---|
| 1A | 6.64 | 63% | 37% | 86% | 14% |
| 1B | 0.92 | 68 | 32 | 91 | 9 |
| 2A | 16.73 | 66 | 34 | 90 | 10 |
| 2B | 1.35 | 66 | 34 | 93 | 7 |
| 3A | 4.50 | 61 | 39 | 82 | 18 |
| 3B | 26.68 | 46 | 54 | 72 | 28 |
| 4A | 19.62 | 55 | 45 | 80 | 20 |
| 4B | 2.98 | 53 | 47 | 76 | 24 |
| 4C | 2.58 | 64 | 36 | 86 | 14 |
| 4D | 0.75 | 65 | 35 | 89 | 11 |
| 5A | 3.37 | 63 | 37 | 87 | 13 |
| 5B | 62.56 | 48 | 52 | 76 | 24 |
| 6A | 25.11 | 47 | 53 | 75 | 25 |
| 6B | 12.54 | 58 | 42 | 85 | 15 |
| 6C | 12.43 | 38 | 62 | 59 | 41 |
| 7A | 11.41 | 46 | 54 | 71 | 29 |
| 7B | 0.06 | 100 | 0 | 100 | 0 |
| 8A | 65.66 | 29 | 71 | 43 | 57 |
| 8B | 13.44 | 39 | 61 | 63 | 37 |
| 9A | 8.62 | 30 | 70 | 44 | 56 |
| 9B | 96.52 | 42 | 58 | 62 | 38 |
| 9C | 0.68 | 53 | 47 | 74 | 26 |
| 9D | 28.60 | 45 | 55 | 68 | 32 |
| 10A | 0.56 | 34 | 66 | 53 | 47 |
| 10B | 105.78 | 28 | 72 | 42 | 58 |
| 10C | 33.61 | 31 | 69 | 45 | 55 |
| 11A | 0.02 | 100 | 0 | 100 | 0 |
| 11B | 0.75 | 52 | 48 | 70 | 30 |
| 11C | 1.71 | 63 | 37 | 88 | 12 |
| 11D | 0.71 | 75 | 25 | 92 | 8 |
| 11E | 8.42 | 52 | 48 | 71 | 29 |
| 12A | 0.14 | 85 | 15 | 92 | 8 |
| 12B | 20.89 | 5 | 95 | 9 | 91 |
| 12C | 2.22 | 73 | 27 | 89 | 11 |
| 12D | 0.25 | 68 | 32 | 86 | 14 |
| 13A | 2.14 | 21 | 79 | 37 | 63 |
| 13B | 0.04 | 75 | 25 | 75 | 25 |
| 13C | 0.10 | 70 | 30 | 90 | 10 |
| 13D | 0.23 | 43 | 57 | 62 | 38 |
| 14 | 34.17 | 23 | 77 | 41 | 59 |
| 15A | 0.07 | 71 | 29 | 100 | 0 |
| 15B | 0.14 | 67 | 23 | 83 | 17 |
| 15C | 2.59 | 12 | 88 | 20 | 80 |
| 15D | 0.08 | 88 | 12 | 88 | 12 |
| 15E | 0.06 | 80 | 20 | 100 | 0 |

TABLE H-5 (Continued)

| Sub-reach Number | Total FAAD 2/ | EAAD 3/ 100-Yr. Resid. (% of Total) | EAAD 4/ 100-Yr. Benef. (% of Total) | EAAD 3/ 50-Yr. Resid. (% of Total) | EAAD 4/ 50-Yr. Benef. (% of Total) |
|---|---|---|---|---|---|
| 16A | 29.74 | 20 | 80 | 35 | 65 |
| 16B | 141.67 | 9 | 91 | 17 | 83 |
| 16C | 0.42 | 24 | 76 | 38 | 62 |
| 16W | 1.07 | 19 | 81 | 27 | 73 |
| 17A | 1.40 | 23 | 77 | 32 | 68 |
| 17B | 5.88 | 11 | 89 | 19 | 81 |
| 18A | 18.63 | 8 | 92 | 15 | 85 |
| 18B | 0.09 | 71 | 29 | 100 | 0 |
| 18C | 0.02 | 100 | 0 | 100 | 0 |
| 18D | 0.04 | 100 | 0 | 100 | 0 |
| 18E | 0.02 | 100 | 0 | 100 | 0 |
| 18F | 0.04 | 0 | 0 | 100 | 0 |
| Subtotal 1A-18F | 837.45 | 32% | 68% | 48% | 52% |
| 51A | 1.57 | 13 | 87 | 25 | 75 |
| 52A | .04 | 67 | 33 | 100 | 0 |
| 53A | 0 | 0 | 0 | 0 | 0 |
| 51B | 11.52 | 5 | 95 | 9 | 91 |
| 52B | 94.67 | 4 | 86 | 9 | 91 |
| 53B | 18.44 | 7 | 93 | 14 | 86 |
| 54A | 0 | 0 | 0 | 0 | 0 |
| 54B | 20.23 | 3 | 97 | 6 | 84 |
| 55 | 3.88 | 16 | 84 | 29 | 71 |
| Subtotal 51A-55 | 150.35 | 5% | 95% | 10% | 90% |
| TOTAL 1A-55 | 987.80 | 27% | 73% | 42% | 58% |

1/ Equivalent average annual damages include existing damages with urbanization hydrology (limited growth future) and affluence to residential contents. January 1978 dollars.
2/ EAAD denotes equivalent average annual damages.
3/ The equivalent average annual damages from flooding with frequencies greater than 100 and 50 years, respectively.
4/ The equivalent average annual damages from flooding with frequencies between 0 and 100 years and 0 and 50 years, respectively. This indicates potential benefits for giving absolute protection up to the 100 and 50 year levels, respectively.

| Item | Street Bridges Fifth | Sixth | Seventh | Ninth |
|---|---|---|---|---|
| (1) Cost of New Bridge | $350,900 | 341,400 | 401,300 | 676,500 |
| (2) Life of New Bridge | 50 yrs | 50 yrs | 50 yrs | 50 yrs |
| (3) Project Life | 50 yrs | 50 yrs | 50 yrs | 50 yrs |
| (4) Remaining Useful Life of Existing Bridge | 32 yrs | 29 yrs | 32 yrs | 17 yrs |
| (5) Extended Life | 18 yrs | 21 yrs | 18 yrs | 33 yrs |
| (6) Interest Rate | 6-5/8% | 6-5/8% | 6-5/8% | 6-5/8% |
| (7) Capital Recovery Factor (6-5/8% 50 yrs) | .069044 | .069044 | .069044 | .069044 |
| (8) Annual Financial Cost of New Bridge (1) x (7) | 24,200 | 23,600 | 27,700 | 46,700 |
| (9) Present Worth Factor, Starting at Year (4) + 1 for (5) Years Compounded at 6-5/8% | 10.3371 | 11.1699 | 10.3371 | 13.2769 |
| (10) Single Payment Present Worth Factor, (4) Years, 6-5/8% | .128384 | .155628 | .128384 | .336044 |
| (11) Benefit Credit at Beginning of Year (4) + 1 (7) x (9) | 250,159 | 263,610 | 286,339 | 620,030 |
| (12) Present Worth of Benefit Credit (11) x (10) | 32,116 | 41,025 | 36,761 | 208,300 |
| (13) Annual Credit (12) x (7) (Rounded) | 2,200 | 2,800 | 2,500 | 14,400 |

63. No benefits are expected for reduced maintenance costs on the bridge because information gathered from the owners indicated that little or no maintenance is required except for routine inspections.

## NED EMPLOYMENT BENEFITS

64. Benefits to be realized through employment of unemployed or underemployed manpower who are directly employed in project construction were also evaluated. These benefits represent wages to workers who would be unemployed in the absence of a project. NED employment benefits were evaluated for plans S3A, S3Ab and L6G, all located in the City of Chester. The City of Chester lies in the Philadlphia Metropolitan Statistical Area (SMSA), which has been declared a labor surplus area by the Manpower Administration of the U.S. Department of Labor. The unemployment rate for the SMSA was 6.4% in December 1977. Delaware County is officially designated as a Titel IV Redevelopment Area under the public Works and Economic Development Act of 1965, as amended. (PL 89-136).

65. Project first costs less supervision and adminsitration, engineering and design, and real estate and relocations equal construction costs. Labor costs were estimated to be 25%, 30%, and 30% of the construction costs for plans L6G, S3A, and S3Ab,

respectively. These percentages are based on District experience for similar construction work. Labor costs include wages to skilled and unskilled workers; and other workers, such as engineers, inspectors, superintendents, home and field office personnel, and a portion of company profits.

66. Corps of Engineers guidance (CE 1105-2-345, Evaluation of NED Employment Benefits, 17 April 1978) provides percentages of hires of unemployed and underemployed workers. The percentages which can be claimed as NED employment benefits are 30% for skilled workers, 45% for unskilled workers, and 35% for other workers for areas with no "local hire" rule. We are aware of no local hire rule in the City of Chester. The following is documentation on the extent of the unemployment problems in the study area:

The total employment in the construction industry in December 1977 was 53,400 for the entire SMSA.

The number of claimants for unemployment compensation in the construction industry for December 1977 was 10,000 for just the Pennsylvania portion of the SMSA. This does not include the number of unemployed construction workers who are no longer eligible for compensation.

Construction industry unemployment is in excess of 20%.

The projects for which NED employment benefits are claimed would employ about 50 workers for one year (assuming year round employment).

67. The following exampled shows how the NED employment benefits were calculated for Plan L6G.

| | | |
|---|---|---|
| Percent of Wages to: | | |
| | Skilled Workers | 40% |
| | Unskilled Workers | 40% |
| | Other Workers | 20% |
| Percent of Workers Previously Unemployed: | | |
| | Skilled Workers | 30% |
| | Unskilled Workers | 45% |
| | Other Workers* | 0 |

* Other Workers, such as; engineers, inspectors, superintendents, office personnel were not considered as previously unemployed. These workers are all probably employed and permanent employees of the construction company.

| | | |
|---|---|---|
| Project First Cost | = | \$2,886,000 |
| Less: E&D and S+A | = | 377,000 |
| Less: Real Estate | = | 22,000 |
| Construction Cost | = | \$2,487,000 |

Labor Costs = \$2,487,000 x 0.25 = \$622,000

Capital Recovery Factor (6-5/8%, 50 years) = .069044

Wages per Category :

| | |
|---|---|
| Skilled | \$249,000 |
| Unskilled | 249,000 |
| Other | 124,000 |
| Total | \$622,000 |

Wages to Previously Unemployed Workers per Category:

| | |
|---|---|
| Skilled | \$ 74,700 |
| Unskilled | 112,000 |
| Other | 0 |
| Total | \$186,700 |

Average Annual NED Employment Benefit
\$186,700 x 0.069044 = \$12,900

## RECREATION BENEFIT ANALYSIS

68. Water based recreation was not possible for the flood control plans considered. Land based recreation was evaluated. The adopted recreation criteria were used to estimate the number of people who could engage in each recreational activity at each recreation area in a year. These units, called activity-days, were translated into visitor-days in order to calculate benefits. A visitor-day was defined as attendance for one recreationist sometime during the course of a day, regardless of the number of activities engaged. Most people visiting a park or recreation area participate in more than one activity. The "Water Oriented Recreation Study of the Upper Delaware River Basin" found that visitors engaged in an average 1.9 activities each in parks with a relatively narrow range of activities. Because of the very limited range of activities to be offered in the area along Chester Creek in Chester, 1.5 activities per person were used. In the areas where picnicking and hiking would be the major activities, visitor-days were estimated by adding picnicking activity-days to 50 percent of hiking activity-days. The underlying assumption was that half of the hikers will also picnic in the area.

69. In order to compare benefits with costs, dollar values were placed on the recreational visitor-day. A range of \$0.75 to \$2.25 was established by the Water Resources Council for general recreational benefit

values. A range from $1.80 to $2.07 was used by the "Water Oriented Recreation Study of the Upper Delaware River Basin" for the large, multi-activity recreation areas they were considering*. Recreation benefits for projects in the Chester Creek Basin were felt to be less than those for the Upper Delaware study and greater than the minimums established by the Water Resources Council. Based on these "envelope conditions", reasonable rates for the Chester Creek Study were estimated as $1.25 for the City of Chester area and $1.00 for the areas having only hiking and picnicking. This rate was multiplied by the annual number of visitor-days to give the estimated annual recreation benefits. Available data indicate that unsatisfied demand in the Chester Creek Basin vicinity is greater than that which could be supplied by these areas. It is therefore assumed that these areas would be utilized if provided.

70. Land based recreation facilities were considered for three reservoir plans (R6, R10, and R13), a levee plan at Toby Farms (L8A and L8B) and evacuation plans for the City of Chester. A summary of the type of recreation benefits and the magnitude of activity which was considered is presented in Table H-6. These benefits represent the potential benefits which the area could provide if they were developed to their practical capacity.

* Water Oriented Recreation Study, Upper Delaware River Basin, Delaware & Sullivan Counties, New Jersey; prepared for the Philadelphia District, Corps of Engineers; prepared by Fhahringer, McCarty, Crey, Inc., Landscape Architects and Engineers, Monroeville, Pennsylvania, July 1974.

TABLE H-6
RECREATION FACILITIES AND BENEFITS
SUMMARY ANALYSIS FOR
SELECTED PLANS 1/

| Location | Reservoir Area (acres) | Hiking Trail (miles) | Picnic Area (acres) | Other Facilities | Annual Visitor Days 3/ | Annual Benefit Jul 75 (thousand of Dollars) 4/ | Annual Benefit Jan 78 (thousand of Dollars) 4/ |
|---|---|---|---|---|---|---|---|
| Dry Reservoir Plans | | | | | | | |
| R6 | 130.9 | 1 | 60 | 1/ | 252,688 | $253 | $298 |
| R10 | 427.0 | 4 | 200 | 1/ | 844,136 | 844 | 996 |
| R13 | 253.4 | 4 | 125 | 1/ | 531,729 | 532 | 628 |
| Levee Plans | | | | | | | |
| Toby Farms | - | 1.3 | 7 | none | 32,749 | 33 | 39 |
| Evacuation Plans | | | | | | | |
| City of Chester | - | 4.5 | 12.4 | 2/ | 58,748 | 74 | 87 |

1/ Other facilities may include playing fields, basketball courts, and canoe access areas.
2/ Facilities include a 2.8 mile bicycle trail, boat ramp, parking lot for 40 cars with trailers, and flush toilets.
3/ Annual Visitor Days = [Sum of (Number of Units in miles acres, etc.) x (People per Unit) x (Turnover Rate) x (Recreation Days per Week) x (Weeks per Summer Season) x $\left(\frac{1}{\text{Seasonal Factor}}\right)$] ÷ (Activities per Person Per Day)

4/ Annual Benefit = (Annual Visitor Days) x (Monetary Benefit per Visitor Day)

# METROPOLITAN
# CHESTER CREEK BASIN
# PENNSYLVANIA

## PERTINENT
## CORRESPONDENCE

APPENDIX 2

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT
CORPS OF ENGINEERS

# APPENDIX 2

## PERTINENT CORRESPONDENCE

TABLE OF CONTENTS

LIST OF TABLES



LIST OF EXHIBITS

## LIST OF EXHIBITS (Continued)

APPENDIX 2

PERTINENT CORRESPONDENCE

Extensive efforts were devoted toward achieving active Federal, state, regional and local participation during the study. Coordination was first initiated for the Plan of Study. This included coordination with appropriate regional and Federal and state agencies, and then agencies in Delaware and Chester Counties (the Counties in which the study was being conducted). Before the completion of the Plan of Study, coordination was intiated with the 21 local municipalities and a large public involvement program was begun.

During Stage II, coordination continued with all appropriate Federal, state, and local agencies, and with the general public. Public involvement was mainly in the form of newsletters, information bulletins, workshops, and public meetings.

Selected items of coordination with the public, Congressmen, Federal, state, county and municipal agencies are presented in Tables 1 through 7 . It should be noted that these tables do not list all the telephone conversations, letters, and meetings which took place during the study. The medium of coordination, the date, and a brief remark to indicate the purpose of the coordination is entered in the tables for each selected item of coordination. It is also indicated in the tables whether any listed correspondence is included as an exhibit of this appendix. If the item of coordination was a general coordination meeting, it is only noted in these tables but documented in Table 8.

Selected items of correspondence are included as Exhibits 1 through 12 . All exhibits which were multi-addressed correspondence have been indicated. This correspondence has been included as supporting documentation as to the degree of coordination undertaken by the District during the Study. It serves as supporting documentation to the evolution of this study from a multi-purpose comprehensive water resources effort to a single-purpose flood water and flood plain management effort. In addition this supporting data also documents the coordination which took place at the end of the Stage II in order to identify potential non-federal sponsors for feasible plans and the coordination which took place at the conclusion of the Study.

A number of abbreviations are used in the tables. Brief explanations of those which may not be selfevident follow.

BOR - Bureau of Outdoor Recreation, United States Department of the Interior
Bor. - Borough
CHESCO - Chester County, Pennsylvania
CE - Corps of Engineers
DELCO - Delaware County, Pennsylvania
DER - Pennsylvania Department of Environmental Resources
DRBC - Delaware River Basin Commission
DVRPC - Delaware Valley Regional Planning Commission
EPA - Environmental Protection Agency
FWS - Fish and Wildlife Service, United States Department of the Interior
HUD - United States Department of Housing and Urban Development
PA - Commonwealth of Pennsylvania
SCS - Soil Conservation Service, United States Department of Agriculture
telecon - telephone conversation
Twp. - Township
UPDATE - Chester Creek Basin Study newsletter
USGS - United States Geological Survey, United States Department of the Interior

AD-A106 781 ARMY ENGINEER DISTRICT PHILADELPHIA PA F/G 13/2
WATER RESOURCES STUDY FOR METROPOLITAN CHESTER CREEK BASIN, PEN--ETC(U)
SEP 78
UNCLASSIFIED DAEN/NAP-12000/WRS-78/09 NL

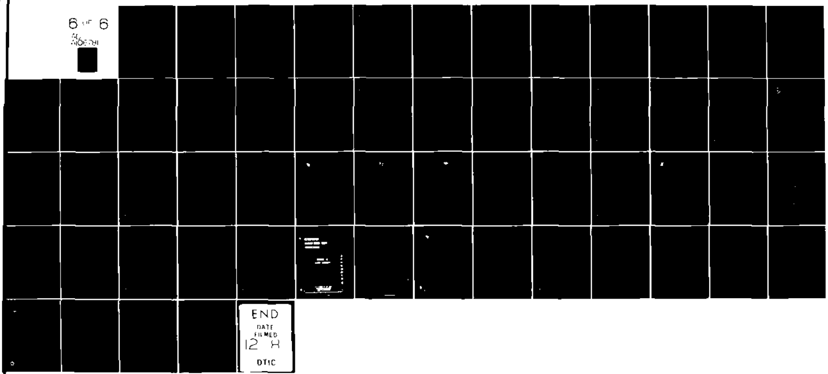


TABLE 1
PUBLIC COORDINATION

| ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|
| **Invitation** 31 October 74 | Invitation to the initial public meeting; mailed to entire mailing list. | |
| Public Meeting 19 Nov 74 | Initial public meeting; held to discuss causes of and possible solutions for flood problems and to obtain data on locations of flood damage areas. | 1 |
| Notice | Notice of availability of transcript of initial public meeting; mailed to entire mailing list. | |
| Transcript | Transcript of the initial public meeting; sent to repositories and those requesting copies. | |
| UPDATE 1 - Apr 75 | Brief history of the study and description of the work in progress; sent to entire mailing list, as were all issues of UPDATE. | |
| Meeting 11 Apr 75 | Meeting with residents and officials of West Goshen Twp. and West Chester Boro to discuss flooding problems. | |
| UPDATE 2 - May 75 | Summary of citizens ideas on flooding as presented to the Corps. | |
| UPDATE 3 - Aug 75 | Description of the planning process. | |
| UPDATE 4 - Sep 75 | Description of types of flood control measures and identification of the study repositories. | |
| UPDATE 5 - Apr 76 | Status of Stage II work and list of flood protection measures under consideration. | |
| UPDATE 6 - Jan 77 | Summary of Stage II studies and transmittal of information bulletin. | |
| Information Bulletin Jan 77 | Presents information on the alternative plans considered in the study. | |
| Meeting 2 Mar 77 | Meeting with residents of Toby Farms section of Chester Twp. to discuss levee plans. | |

TABLE 1 (Cont'd)
PUBLIC COORDINATION

| ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|
| Invitation 28 Mar 77 | Invitation to the second public meeting; sent to entire mailing list. | |
| UPDATE 7 - Apr 77 | Reminder about public meeting and description of the coordination of study results with citizens and their representatives. | |
| Handout 27 Apr 77 | Handout on where we are in the study process distributed at the second public meeting. | |
| Public Meeting 27 Apr 77 | Second public meeting; presentation on the alternative plans considered and those recommended for further study. | 2 |
| UPDATE 8 - Jun 77 | Notice of availability of transcript. | |
| Transcript | Transcript of the second public meeting. | |
| UPDATE 9 - Nov 77 | Summary of Stage II findings and recommendations. | |
| Information Bulletin Jul 78 | Presents information on the study plans which were considered further and the final study recommendations. | |
| Invitation 28 Jul 78 | Invitation to the final public meeting; sent to the entire mailing list. | |
| Public Meeting 30 Aug 78 | Final public meeting; presentation on the final study recommendations. | 3 |
| Transcript | Transcript of the final public meeting. | |

TABLE 2
SELECTED ITEMS
CONGRESSIONAL COORDINATION

| CONGRESSIONAL REPRESENTATIVE | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| Senate Committee on Public Works | Resolution 2 Nov 71 | Authorization of study | 4 |
| House of Representatives Committee on Public Works | Resolution 2 Dec 71 | Authorization of study | 5 |
| Senator Schweiker | Senator Schweiker Letter 27 Mar 73 | Request CE consideration of "interim" flood control studies. | |
| | Senator Schweiker Letter 12 Jul 73 | Request CE to expedite Chester Creek efforts. Reply made 3 Aug 73. | |
| Representative Ware | Representative Ware Letter 11 Nov 74 | Suggestion for interim flood control measures | |
| Representative Edgar & Representative Schulze | CE letter 24 Dec 74 | Transmittal of information on the study to new Congressmen. | |
| Senator Scott, Senator Schweiker, Representa- Eshelman, Representative Edgar, & Representative Schulze | CE letter 28 Jan 75 | Transmittal of transcript of initial public meeting | |
| Representative Schulze | CE letter 10 Feb 75 | Information on status of the study and study scheduling | |

TABLE 2 (Cont'd)
SELECTED ITEMS
CONGRESSIONAL COORDINATION

| CONGRESSIONAL REPRESENTATIVE | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| Senator Scott, Senator Schweiker, Representative Eshelman, Representative Edgar, and Representative Schulze | CE letter 11 Sep 75 | Transmittal of copies of final plan of study | |
| Representative Schulze | CE - Schulze Meeting 9 Feb 77 | Discussion on Stage II results and non-federal costs | |
| Representative Edgar | CE - Edgar Meeting 25 Feb 77 | Discussion on Stage II results and non-federal costs | |
| Senator Schweiker, Senator Heinze, Representative Edgar, and Representative Schulze | CE letter 12 Jul 77 | Transmittal of transcript of Stage II public meeting | |

TABLE 3
SELECTED ITEMS
FEDERAL COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| All | CE letter 1 Jun 73 | Notification of initiation of study. | |
| | CE letter 26 Jul 73 | Transmittal of preliminary draft of the plan of study. | |
| | CE letter 10 Sep 75 | Transmittal of the plan of study. | |
| | CE letter 6 Dec 76 | Transmittal of draft copy of Profile for review and comment. | |
| | CE letter 4 Jan 77 | Transmittal of advance copy of an information bulletin on alternatives for review and comment. | |
| | CE letter 27 Jul 78 | Transmittal of draft report for review & comment. | 6 |
| BOR | CE-BOR meeting 25 Jun 73 | Discussion of Urban Studies Program, the Chester Creek Study, and on-going BOR activities. | |
| | BOR letter 14 Sep 73 | Comments on the possible role of BOR in the study. | |
| | CE-BOR meeting 22 Apr 74 | Discussion of possible role of BOR in the study. | |
| | BOR letter 4 Jan 77 | Reply to CE letter 6 Dec 76 requesting comments on Profile; no comments made. | |
| | BOR letter 12 Jan 77 | Reply to CE letter 4 Jan 77 requesting comments on Information Bulletin; no comments made. | |
| EDA | EDA telecon Jun 73 | No coordinator to be assigned. No FDA involvement in study. | |
| EPA | CE-EPA meeting 15 Jun 73 | Discussion of Urban Studies Program, the Chester Creek Study, and on-going EPA activities. | |
| | EPA letter 4 Sep 73 | Comments on the draft plan of study and role of EPA in the study. | |
| | CE-EPA meeting 5 Dec 73 | Discussion on study role in waste water management. | |
| | EPA letter 7 Jan 74 | Confirmation of some of the items discussed at the 5 Dec 73 meeting. | |

TABLE 3 (Cont'd)
SELECTED ITEMS
FEDERAL COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| FWS | CE-FWS meeting 12 Jul 73 | Discussion of Urban Studies Program, the Chester Creek Study, and on-going BSF&W activities. | |
| | CE-FWS meeting 18 Aug 75 | Discussion of FY 76 program of FWS reports and any special needs. | |
| | CE letter 29 Aug 75 | Request for preliminary report on Fish and Wildlife resources. | |
| | FWS letter 20 Nov 75 | Preliminary report on fish and wildlife resources. | |
| | CE-FWS meeting 14 Oct 76 | Discussion of FWS work in FY 77 through FY 79. | |
| | FWS letter 2 Nov 76 | Cost estimates for items discussed at the 14 Oct 76 meeting. | |
| | FWS letter 31 Jan 77 | Comments on the Profile in response to CE letter 6 Dec 76. | |
| | FWS letter 15 Feb 77 | Comments on alternative plans in response to CE letter 4 Jan 77. | |
| | CE-FWS meeting 21 Apr 77 | Coordination meeting on status of FY 77 work and schedule for FY 78. | |
| | FWS letter 14 Jul 77 | Interim report on proposed flood control plans. | |
| | FWS letter 4 Aug 78 | Comments on draft report. | 7 |
| HUD | CE-HUD meeting 12 Jan 73 | Discussion of Urban Studies Program, the Chester Creek Study, and on-going HUD activities. Assignment of a study coordinator for the area office. | |
| | HUD letter 28 Aug 73 | Comments on the draft plan of study and role of HUD in the study. | |
| | CE-HUD meeting 11 Dec 73 | Data and information support. | |
| | CE letter 21 Nov 75 | Coordination of CE and HUD plans concerning levee at Toby Farms. | |
| SCS | CE-SCS meeting 22 Jun 73 | Discussion of Urban Studies Program, the Chester Creek Study, and on-going SCS activities. | |

TABLE 3 (Cont'd)
SELECTED ITEMS
FEDERAL COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| | SCS letter 3 Jul 73 | Confirmation of some of the items discussed at the 22 Jun 73 meeting. | |
| | SCS letter 20 Aug 73 | Comments on the draft plan of study and possible role of SCS in the study. | |
| | CE-SCS meetings | | |
| | 20 Dec 73 & 31 Jan 74 | Data and information support. | |
| | CE letter 11 Feb 73 | Data and information support. | |
| | SCS letter 22 Feb 74 | Data and information support. | |
| | CE letter 24 Apr 74 | Data and information support. | |
| | SCS letter 15 Jul 75 | Transmittal of Flood Insurance Studies for Thornbury and Concord Townships. | |
| USGS | CE-USGS meeting 12 Jun 73 | Discussion of Urban Studies Program, the Chester Creek Study, and on-going USGS activities. | |
| | USGS letter 30 Aug 73 | Comments on the draft plan of study and role of USGS in the study. | |

TABLE 4
SELECTED ITEMS
REGIONAL COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| Both | CE letter 26 Jul 73 | Transmittal of preliminary draft of the plan of study. | |
| | 23 Aug 73 | GENERAL COORDINATION MEETING | |
| | 30 Oct 73 | GENERAL COORDINATION MEETING | |
| | 20 Nov 73 | GENERAL COORDINATION MEETING | |
| | CE letter 11 Dec 73 | Redirection of the study. | |
| | CE letter 20 Feb 74 | Summarization of the status of the study effort. | |
| | CE letter 10 Sep 75 | Transmittal of finalized copy of the plan of study. | |
| | CE letter 12 Nov 76 | Transmittal of draft copy of Profile for review and comment. | |
| | CE letter 4 Jan 77 | Transmittal of advance copy of an information bulletin on alternatives for review and comment. | |
| DRBC | CE telecon 21 May 73 | Notification of initiation of study. | |
| | CE-DRBC meeting 1 Jun 73 | Discussion of Urban Studies Program, the Chester Creek Study, and on-going DRBC activities. | |
| | DRBC letter 12 Nov 73 | Statement of no need of a comprehensive study. | |
| | CE-DRBC meeting 7 Dec 73 | Discussion of Urban Studies Program and current development of plans of study. | |
| | DRBC letter 27 Feb 74 | Restatement of no need of a comprehensive study. | |
| | DRBC letter 10 Feb 77 | Comments on alternative plans in response to CE letter 4 Jan 77. | |
| DVRPC | CE-DVRPC meeting 15 May 73 | Discussion of Urban Studies Program, the Chester Creek Study, and on-going DVRPC activities. | |
| | CE letter 7 Jun 73 | Notification of initiation of study. | |
| | CE-DVRPC meeting 16 Aug 73 | Discussion of the draft plan of study and role of DVRPC in the study. | |
| | CE letter 11 Dec 73 | Redirection of the study. | |
| | CE-DVRPC meeting 11 Dec 73 | Data and information support. | |
| | CE letter 20 Feb 74 | Summarization of the status of the study effort. | |
| | DVRPC letter 18 Jan 77 | Comments on Profile in response to CE letter 12 Nov 76. | |

TABLE 5
SELECTED ITEMS
STATE COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| DER | DER letter 17 Apr 73 | Request for immediate action on flood control. | |
| GOVERNOR | CE letter 17 Apr 73 | Notification of initiation of study. | |
| DER | DER letter 4 May 73 | Response for the Governor with the assignment of a study coordinator. | |
| | CE-DER meeting 10 May 73 | Discussion of Urban Studies Program, the Chester Creek Study, and on-going DER activities. | |
| | CE-DER meeting 5 Jun 73 | Discussion of water resources development in Pennsylvania with respect to both quality and quantity. | |
| | CE letter 26 Jul 73 | Transmittal of preliminary draft of the plan of study. | |
| | 23 Aug 73 | GENERAL COORDINATION MEETING | |
| | 30 Oct 73 | GENERAL COORDINATION MEETING | |
| | DER letter 18 Oct 73 | Assignment of second study coordinator for water quality aspects of the study. | 8 |
| | DER letter 19 Nov 73 | Statement of no need of a comprehensive study. | |
| | 20 Nov 73 | GENERAL COORDINATION MEETING | |
| | CE letter 11 Dec 73 | Redirection of the study. | |
| | CE-DER meeting 18 Dec 73 | Discussion of the role of Urban Studies in Pennsylvania and the scope of the Chester Creek Study. | |
| | CE letters 24 Jan 74 | Redefinition of the role and scope of the Chester Creek Study. | |
| | CE-DER meeting 1 Feb 74 | Discussion of the role of the Corps' Urban Studies Program in Pennsylvania. Attended by all Corps' Districts in Pennsylvania. | |
| | DER letter 11 Feb 74 | Response and comment to the 24 Jan 74 letter from CE. | |
| | DER letter 13 Feb 74 | Response and comment to the 24 Jan 74 letter from CE. | |
| | CE letter 20 Feb 74 | Summarization of the status of the study. | |
| | DER letter 8 Apr 74 | Comments to the 20 Feb 74 letter from CE. | |

TABLE 5 (Cont'd)
SELECTED ITEMS
STATE COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| DER (cont'd) | DER letter 3 May 74 | Request for Corps participation in some aspects of the State's water quality management study. | |
| PennDOT | PennDOT letter 14 May 74 | Data and information support. | |
| DER | DER letter 24 Feb 75 | Inquiry on status of the study. | |
| | CE letter 21 Mar 75 | Reply to DER letter 24 Feb 75 inclosing draft plan of study. | |
| PennDOT | CE-PennDOT meeting 9 Apr 75 | Data and information support. | |
| | CE-PennDOT meeting 17 Jul 75 | Data and information support. | |
| DER | CE letter 10 Sep 75 | Transmittal of the plan of study. | |
| | CE-DER telecon 10 Oct 75 | Data and information support. | |
| | DER letter 14 Oct 75 | Data and information support. | |
| | CE letter 4 Nov 76 | Request for information on DER projects and studies in basin. | |
| DER, Fish & Game Com. | CE letter 12 Nov 76 | Transmittal of draft copies of Profile for review and comment | |
| DER | DER letter 17 Nov 76 | Reply to CE letter 4 Nov 76. | |
| | CE-DER meeting 8 Dec 76 | Coordination of Stage II results. | |
| DER, Fish & Game Com. | CE letter 4 Jan 77 | Transmittal of advance copy of an information bulletin on alternatives for review and comment. | |

TABLE 5 (Cont'd)
SELECTED ITEMS
STATE COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| PennDot | PennDOT letter 18 Jan 77 | Data and information support. | |
| Fish Comm. | Fish Comm. letter 24 Jan 77 | Comments on alternative plans in response to CE letter 4 Jan 77. | |
| DER | DER letter 1 Feb 77 | Comments on alternative plans in response to CE letter 4 Jan 77. | |
| | DER letter 8 Feb 77 | Comments on Profile in response to CE letter 12 Nov 76. | |
| PennDOT | PennDOT letter 22 Aug 77 | Data and information support. | |
| DER, Fish & Game Com.. Community Affairs, PennDOT, State Clearinghouse | CE letter 27 Jul 78 | Transmittal of draft report for review & comment. | 6 |
| DER | DER letter 28 Aug 78 | Comments on draft report. | 9 |

TABLE 6
SELECTED ITEMS
COUNTY COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| Both | CE letter 21 May 73 | Notification of initiation of study. | |
| | CE letter 26 Jul 73 | Transmittal of preliminary draft of the plan of study. | |
| | 23 Aug 73 | GENERAL COORDINATION MEETING | |
| | 30 Oct 73 | GENERAL COORDINATION MEETING | |
| | 20 Nov 73 | GENERAL COORDINATION MEETING | |
| | CE letter 11 Dec 73 | Redirection of the study. | |
| | CE letter 20 Feb 74 | Summarization of the status of the study effort. | |
| | 11 Sep 74 | MUNICIPAL COORDINATION MEETING | |
| | 12 Nov 74 | COORDINATION MEETING | |
| | CE letter 10 Sep 75 | Transmittal of the plan of study. | |
| | CE letter 12 Nov 76 | Transmittal of draft copy of Profile for review and comment. | |
| | CE letter 4 Jan 77 | Transmittal of advance copy of an information bulletin on alternatives for review and comment. | |
| | CE letter 27 Jul 78 | Transmittal of draft report for review & comment. | 6 |
| CHESCO | CE-CHESCO meeting 29 May 73 | Discussion of Urban Studies Program, the Chester Creek Study, and on-going CHESCO activities. | |
| | CE-CHESCO meeting 19 Oct 73 | Data and information support. | |
| | CE letter 1 May 74 | Data and information request. | |
| | CHESCO letter 18 Sep 75 | Data and information support. | |
| | CHESCO letter 22 Nov 76 | Comments on Profile in response to CE letter 12 Nov 76. | |
| | CHESCO letter 7 Feb 77 | Comments on alterantive plans in response to CE letter 4 Jan 77. | |
| DELCO | CE-DELCO meeting 1 Jun 73 | Initial contact with the county engineer. | |
| | CE-DELCO meeting 12 Jun 73 | Discussion of Urban Studies Program, the Chester Creek Study and on-going DELCO activities. | |
| | DELCO letter 21 Aug 73 | Statement of goals, needs, and on-going activities. | |

SELECTED ITEMS
COUNTY COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| DELCO (cont'd) | DELCO letter 2 Nov 73 | Confirmation of 21 Aug 73 letter. | |
| | DELCO letter 27 Nov 73 | Statement of stream encroachment as an additional need of the study area. | |
| | CE-DELCO meeting 4 Dec 73 | Data and information support. | |
| | DELCC letter 6 Nov 74 | Data and information support. | |
| | DELCO letter 2 Jun 75 | Data and information support. | |
| | DELCO letter 9 Jun 75 | Data and information support. | |
| | DELCO letter 28 Jan 76 | Transmittal of draft Open Space, Park, and Recreation Study. | |
| | CE-DELCO meeting 13 Dec 76 | Coordination of Stage II findings and discussion of non-Federal participation. | |
| | DELCO letter 25 Jan 77 | Comments on Profile in response to CE letter 12 Nov 76. | |
| | CE-DELCO meeting 10 Feb 77 | Briefing on alternatives for County Council. | |
| | CE-DELCO-Municipalities meeting 15 Feb 77 | MUNICIPAL COORDINATION MEETING | |
| | Telecon 17 Mar 77 | DELCO missed 15 Mar deadline for assurances and as a result is having trouble preparing for P.M. | |
| | CE letter 23 Mar 77 | Deadline for assurances extended to 1 Apr. | |
| | DELCO letter 31 Mar 77 | DELCO cannot meet 1 Apr deadline due to lack of municipal responses and questions on Plan R10. | |
| | Telecon 11 May 77 | Questionnaire responses from P.M. will be sent to CE; PDO requested to attend 19 May Planning Commission meeting. | |
| | Telecon 12 May 77 | PDO requested not to attend 19 May meeting; Planning Commission recommendations to be presented to County Council on 24 May. | |
| | DELCO letter 24 May 77 | Notification that action on Corps plans was tabled at 19 May Planning Commission meeting. | |

TABLE 6 (Cont'd)
SELECTED ITEMS
COUNTY COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| DELCO (cont'd) | CE-DELCO meeting 3 Jun 77 | Discussion of local assurances. | |
| | Telecon 8 Jul 77 | County Council wants more information on positions of Chester Twp. and City of Chester before making any decision. | |
| | CE letter 21 Jul 77 | Study terminated if responses not received by 15 Aug deadline. | |
| | DELCO letter 2 Aug 77 | Requests technical assistance for flood proofing, flood plain info., stream obstructions, and stormwater management. | |
| | DELCO letter 15 Aug 77 | Transmittal of County Council Resolution on sponsorship of flood control. | 10 |
| | CE letter 7 Oct 77 | Response to DELCO letter 15 Aug 77; sponsorship of plans in City of Chester is accepted; all other plans eliminated. | 11 |
| | Telecon 19 Dec 77 | Notification by CE of negative findings on plans in City of Chester. | |
| | CE-DELCO meeting 16 Mar 78 | Presentation of the negative findings to the County Planning Commission. | |

TABLE 7
SELECTED ITEMS
MUNICIPAL COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| All | CE letter 7 Nov 73 | Notification and status of the study. | |
| | CE letter 11 Dec 73 | Redirection of the study. | |
| | CE letter 20 Feb 74 | Summarization of the status of the study effort. | |
| | CE letter 20 Aug 74 | Invitation to coordination meetings. | |
| | 11 Sep 74 | MUNICIPAL COORDINATION MEETING | |
| | CE letter 12 Nov 76 | Transmittal of draft copy of Profile for review and comment. | |
| | CE letter 4 Jan 77 | Transmittal of advance copy of an information bulletin on alternatives for review and comment. | |
| | CE letter 27 Jul 78 | Transmittal of draft report for review & comment. | 6 |
| All DELCO | 15 Feb 77 | MUNICIPAL COORDINATION MEETING | |
| Aston Twp. | CE letter 29 Jul 76 | Transmittal of water surface profiles. | |
| | CE-Aston meeting 15 Oct 76 | Discussions on status of Chester study and DER's channel work. | |
| | CE-Aston meeting 26 Jan 77 | Discussions on status of study and results of Stage II. | |
| Chester City | CITY letter 31 Aug 73 | Request for the inclusion of the City in any efforts on the Chester Creek Basin. | |
| | CITY letters 19 Nov 73 | Statement of goals, needs, and on-going activities. | |
| | 20 Nov 73 | GENERAL COORDINATION MEETING | |
| | CE-CITY meeting 11 Dec 73 | Discussion of on-going city planning and redevelopment activities. | |
| | CE-CITY meeting 18 Sep 74 | Coordination with Planning Commission on flood damage survey. | |
| | 12 Nov 74 | COORDINATION MEETING | |
| | CITY letter 7 May 75 | Data and information support. | |
| | CITY letter 9 Jun 75 | Comments on the study from Redevelopment Authority. | |
| | CE letter 15 Jul 75 | Reply to City letter 9 Jun 75. | |

TABLE 7 (Cont'd)
SELECTED ITEMS
MUNICIPAL COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| Chester City (Cont'd) | CITY letter 21 Aug 75 | Comments on the study from Redevelopment Authority. | |
| | CE-CITY meeting 30 Oct 75 | Coordination with Planning Commission and Redevelopment Authority. | |
| | CE-CITY meeting 21 Sep 76 | Discussion on status of study and results of Stage II. | |
| | CE-CITY meeting 18 Jan 77 | Discussion of Stage II results and local assurances. | |
| | CE telecon 19 Dec 77 | Notification of negative findings. | |
| Chester Heights Boro. | CHESTER HEIGHTS letter 13 Mar 74 | Identification of flood problem areas. | |
| | CE-BORO meeting 18 Sep 74 | Coordination on damage survey. | |
| | CE-BORO meeting 19 Jan 77 | Discussion of Stage II results, particularly R10. | |
| | BORO resolution 7 Feb 77 | Borough Council resolution opposing any reservoir in the Borough. | 12 |
| Chester Twp. | CE letter 18 May 76 | Notification that CE can not grant funds to Twp. for levee design. | |
| | CE-TWP meeting 16 Nov 76 | Discussion of CE findings on Toby Farms and Twp. position. | |
| | TWP letter 12 Aug 77 | Transmittal of Board of Supervisors resolution against Toby Farms levee. | 13 |
| Concord Twp. | CE-TWP meeting 19 Sep 74 | Coordination on damage survey. | |
| | CE-TWP meeting 19 Jan 77 | Discussion on status of study and Stage II results. | |
| | TWP letter 27 Apr 77 | Notification that Twp. has no funds to commit to a dry reservoir. | |
| | TWP letter 3 May 77 | Notification that Board of Supervisors rejected dry reservoir plans. | 14 |

TABLE 7 (Cont'd)
SELECTED ITEMS
MUNICIPAL COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| Middletown Twp. | CE-TWP meeting 19 Sep 74 | Coordination on damage survey. | |
| | CE-TWP meeting 17 Jan 77 | Discussion on status of study and Stage II results. | |
| Thornbury Twp. (CHESCO) | CE-TWP meeting 24 Sep 74 | Coordination on damage survey. | |
| Upland Boro. | CE letter 10 May 73 | Response that the study has been initiated. | |
| | CE letter 19 Oct 73 | Confirmation of future coordination with local municipality as the study effort progresses. | |
| | BORO telecon 31 Jan 74 | Inquiry on status of the study. | |
| | CE-BORO meeting 17 Sep 74 | Coordination on damage survey. | |
| | BORO letter 10 May 77 | Statement of support for a project but giving no local assurances. | 15 |
| | CE letter 26 May 77 | Reply to Boro. letter 10 May 77. | |
| West Chester Boro. | CE-WEST CHESTER-WEST GOSHEN meeting 7 Jan 74 | Discussion of flood control needs. | |
| | WEST CHESTER letter 24 Jan 74 | Assignment of a study coordinator. | |
| | CE-WEST CHESTER-WEST GOSHEN meeting 23 Sep 74 | Coordination on damage survey. | |
| | CE telecon 26 Jan 77 | Discussion of negative findings in West Chester area. | |
| West Goshen Twp. | CE-WEST CHESTER-WEST GOSHEN meeting 7 Jan 74 | Discussion of flood control needs | |
| | WEST GOSHEN letter 23 Jan 74 | Assignment of a study coordinator. | |

TABLE 7 (Cont'd)
SELECTED ITEMS
MUNICIPAL COORDINATION

| AGENCY 1/ | ITEM OF COORDINATION | REMARK | EXHIBIT NO. |
|---|---|---|---|
| West Goshen Twp (cont'd) | CE-WEST CHESTER-WEST GOSHEN meeting 23 Sep 74 | Coordination on damage survey. | |
| | CE telecon 26 Jan 77 | Discussion of negative findings in West Chester area. | |
| Westtown Twp. | CE-WESTTOWN meeting 30 Sep 74 | Coordination on damage survey. | |

TABLE 8
GENERAL COORDINATION MEETINGS

| MEETING DATE | PARTICIPANTS 1/ | REMARKS |
|---|---|---|
| 23 Aug 73 | CE, DRBC, DER, CHESCO, DELCO, DVRPC | Common meeting with emphasis on the Metropolitan Christina River Basin Study. Presentation on the Corps Urban Studies Program, requirements of an urban study, and procedures for the development of a plan of study for an urban study. Mechanism for completion of a plan of study was established. |
| 30 Oct 73 | CE, DRBC, DVRPC, DER, CHESCO, DELCO | A reassurance of the need for the Chester Creek Study was obtained from the participants. Possibility of interim flood control studies was discussed. |
| 20 Nov 73 | CE, DRBC, DVRPC, DER, CHESCO, DELCO, CITY OF CHESTER, BOROUGH OF UPLAND, CHESTER TOWNSHIP | Presentation and discussion of background material, goals and purposes of an urban study, goals of an urban study plan, study methodology, components of the plan, study participation, plan of study and study schedule. The needs and priorities of the Chester Creek Basin were discussed and flood water and flood plain management established as an immediate priority. Status of the investigation of interim flood control studies was presented. |
| 11 Sep 74 | CE, CHESCO, DELCO, ASTON, BROOKHAVEN, CITY OF CHESTER, CHESTER TWP., EDGMONT, MIDDLETOWN, THORNBURY (DELCO), THORNBURY (CHESCO), UPLAND, W. CHESTER, W. GOSHEN | Presentation by CE on work accomplished to date; discussion of this work by DELCO; CE presentation on study activities, public involvement, and flood cost survey; general discussion on these subjects; CE presentation on flood damage areas already identified; identification of additional damage areas. |

TABLE 8 (Cont'd)
GENERAL COORDINATION MEETINGS

| MEETING DATE | PARTICIPANTS 1/ | REMARKS |
|---|---|---|
| 12 Nov 74 | CE, SCS, CHESCC, DELCO, CITY OF CHESTER, CIVIC GROUPS | Familiarize attendees with the study; discuss the public involvement program; go over the agenda for the Initial P.M.; identify key issues; show film on flood control; discuss film and record comments. |
| 15 Feb 77 | CE, DELCO, ASTON, BETHEL, BROOKHAVEN, CITY OF CHESTER, CHESTER HEIGHTS, CONCORD, MIDDLETOWN, THORNBURY, UPLAND | Summary of progress of study to date; presentation on Stage II studies and results; presentation on structural plans being considered for Stage III; discussion of these plans; responses from municipalities on the acceptability of the plans. |

EXHIBIT 1

## INITIAL PUBLIC MEETING

DATE - 19 Nov 74

PLACE - Northley Jr. High School, Aston, Pa.

PRESIDING OFFICER - Colonel C. A. Selleck, Philadelphia District Engineer

PURPOSE OF MEETING - To inform the public of the study, to present the general causes of flooding and possible solutions, to obtain the public's views on its flooding problems and their suggestions for solutions, and to initiate the public involvement program.

NUMBER OF ATTENDEES - 67

NUMBER OF SPEAKERS - 16

FORMAT OF MEETING - After a general presentation the meeting broke up into 4 discussion groups. Each discussed one of these topics: study authorization, funding and programming; flooding problems; flood water and flood plain management solutions; and environmental and social concerns. The results of the 4 group discussions were summarized for the entire audience. The floor was then opened to public discussion.

SUMMARY OF RESULTS - In the flooding problems group two new residential damage areas were discovered. In the flood water and flood plain management solutions group, the discussion centered around dredging of the creek, the costs and effects of studies already completed, and regulations concerning encroachment on streams. Dry dams were also discussed. The comments in the environmental and social concerns group centered on uncontrolled development, effects of flood plain restrictions, and the possibility of a joint task force including environmental groups and local governments. The speakers during the public discussion generally called for the flooding problems to be solved as quickly as possible.

EXHIBIT 2

## STAGE II PUBLIC MEETING

DATE - 27 Apr 77

PLACE - Northley Jr. High School, Aston, Pa.

PRESIDING OFFICER - Colonel H.V. Dutchyshyn, Philadelphia District Engineer

PURPOSE OF MEETING - To discuss the Stage II study findings and tentative recommendations and to hear the opinions and concerns of the public before making final recommendations.

NUMBER OF ATTENDEES - 68

NUMBER OF SPEAKERS - 23

FORMAT OF MEETING - After the status of the study was reported, presentations were made on all the alternatives which were studied and particularly those tentatively recommended for further study. The floor was then opened to public discussion.

SUMMARY OF RESULTS - The speakers generally fell into one of two categories, residents of the flood-prone areas in the lower portion of the Basin and residents of upstream areas which would be adversely affected by proposed solutions. The flood-prone area residents would benefit from the implementation of any flood control plans and were generally in favor of constructing flood control projects as soon as possible. The upstream residents opposed construction of dry dams which would take homes and land from their communities to benefit those living downstream. Most of the speakers, however, indicated that they could understand the other group's point of view.

EXHIBIT 3

FINAL PUBLIC MEETING

DATE - 30 Aug 78

PLACE - Northley Jr. High School, Aston, Pa.

PRESIDING OFFICER - Colonel James G. Ton, Philadelphia District Engineer

PURPOSE OF MEETING - To present the final study findings and recommendations and to hear the public's views and comments before making a report to Congress.

NUMBER OF ATTENDEES - 23

NUMBER OF SPEAKERS - 8

FORMAT OF MEETING - The results of the investigations on the three plans which were studied further were summarized, the study findings were reviewed, and the proposed recommendation to Congress was presented. Statements and comments were then received from the audience followed by a questions and answer session.

SUMMARY OF RESULTS - Most of the speakers, particularly those from the lower portion of the Basin, expressed dissapointment and frustration over the inability of the Corps to recommend a Federal flood control project. Representatives of the City of Chester were particularly upset that structural measures could not be built there. Chester County expressed support for the Corps recommendation of flood plain management. There was considerable discussion of the reasons the Corps could not build any projects in the Basin.

..92nd.. Congress EXHIBIT 4

..1st... Session

UNITED STATES SENATE
Committee on Public Works

**********************
*A TYPED COPY OF *
*ORIGINAL RESOLUTION*
**********************

COMMITTEE RESOLUTION

RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE UNITED STATES SENATE,

That the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the report of the Chief of Engineers on the Delaware River and Tributaries, New York, New Jersey, Pennsylvania, and Delaware, published as House Document Numbered 522, Eighty-seventh Congress, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at the present time, with particular reference to providing improvements in the interest of flood control, regional water supply and waste water management, water quality control, recreation, and other measures for the enhancement and protection of the environment, in the Chester Creek Watershed in Delaware and Chester Counties, Pennsylvania.

Adopted:..November.2,.1971 .........................

/S/ Jennings Randolph, Chairman

(At the request of Senator Richard S. Schweiker of Pennsylvania)
and
Senator Hugh Scott

EXHIBIT 5

Committee on Public Works
HOUSE OF REPRESENTATIVES, U.S.
Washington, D.C. 20515

*********************
*TYPED COPY OF *
*ORGINAL RESOLUTION*
*********************

R E S O L U T I O N

Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports of the Chief of Engineers on the Delaware River and Tributaries, New York, New Jersey, Pennsylvania, and Delaware, printed in House Document No. 522, 87th Congress, 2nd Session, and other pertinent reports, with a view to determining whether any modifications of the recommendations contained therein are advisable at the present time, with particular reference to providing improvements in the interest of flood control, regional water supply and wastewater management, water quality control, recreation, and other measures for the enhancement and protection of the environment, in the Chester Creek Basin in Delaware and Chester Counties, Pennsylvania.

Adopted: December 2, 1971

Attest: .........................
/S/ John A. Blatnik, M.C.
Chairman

Requested by: Hon. John H. Ware

EXHIBIT 6

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-R

27 July 1978

MULTI-ADDRESSED LETTER - COORDINATION OF REPORT

See attached List

The Corps of Engineers is completing a study of the feasibility of providing flood protection for the Chester Creek Basin, Chester and Delaware Counties, Pennsylvania.

All potential structural and non-structural solutions to the Basin's flood problems were considered. Forty-seven plans were investigated. Twelve plans were identified as having potential for development as solutions to the flood problems. These plans were recommended by us for further study. However, only two plans in the City of Chester received local sponsorship. More detailed study of these plans has shown that they can not be economically justified.

We have completed our study and will recommend to Congress that no flood control projects be authorized by the United States at this time. The reasons for this recommendation are:

a. Lack of economic justification of most plans.

b. Strong opposition by local officials and the public on several plans.

c. The stated inability of Delaware County and local communities to financially support some plans.

d. The non-interest of local officials to assume liability and provide public monies for flood control improvements to private property. (This applied to flood proofing)

e. Implementation of several plans is clearly not a Corps responsibility.

We have found that the best action is for local interests to implement a flood plain management program for the Basin and to undertake channel clearance under existing bridges.

NAPEN-R

We would appreciate receiving any comments you may care to make on the proposed recommendation. The inclosed Draft Report should be helpful to you in fulfilling our request. We plan to conclude this study in September and would appreciate a response by the 25th of August. If no response is received by this date, we will assume that you have no comments.

We will conduct a public meeting on 30 August 1978 in Aston, Delaware County. We will provide additional information concerning the public meeting at a later date.

If you need additional information or have any questions, please contact Mr. Paul Gaudini, the Study Manager, or Mr. James J. Smyth, Chief of my Basin Planning Section. Both are members of the Planning Branch and may be reached by calling (Area Code 215) 597-4714.

Sincerely yours,

F. W. VINCI
Acting Chief, Engineering Division

1 Incl
As stated

## COORDINATION OF REPORT

## CHESTER CREEK STUDY

### Federal and Regional Agencies

Ms. Dianne Semingson
Regional Representative of
the Secretary of Commerce
William J. Green Federal Building
600 Arch Street, Room 1048
Philadelphia, PA 19106

Regional Hydrologist
Eastern Region
NOAA, National Weather Service
585 Stewart Avenue
Garden City, N.Y. 11530

Mr. Thomas C. Maloney
Regional Administrator
HUD Regional Office
625 Walnut Street
Philadelphia, PA 19106

Mr. Anthony M. Corbisiero
Acting Regional Director
U. S. Department of the Interior
Heritage, Conservation, and
Recreation Service
600 Arch Street, Room 9310
Philadelphia, PA 19106

Director, Northeast Region
National Park Service
143 South Third Street
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Mr. Gerald M. Hansler, Executive Director
Delaware River Basin Commission
P. O. Box 7360
West Trenton, NJ 08628

Regional Hydrologist
Geological Survey
National Center - Mail Stop 433
12291 Sunrise Valley Drive
Reston, VA 22092

Water Resources Coordinator
U. S. Department of Commerce
Assistant Secretary for Policy
Washington, D.C. 20230

Mr. Don Morrow
Area Manager
HUD Area Office
625 Walnut Street
Philadelphia, PA 19106

Mr. Jack J. Schramm
Regional Administrator
EPA, Region III
6th and Walnut Streets
Philadelphia, PA 19106

Mr. Charles J. Kulp
Field Supervisor
U. S. Fish & Wildlife Service
112 West Foster Avenue
State College, PA 16801

Mr. Walter Johnson
Executive Director
Delaware Valley Regional
Planning Commission
3rd Floor, Penn Towers Building
1819 J. F. Kennedy Boulevard
Philadelphia, PA 19103

State Conservationist
U.S.D.A., Soil Conservation
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Box 985 Federal Square Station
Harrisburg, PA 17108

District Chief, WRD
U. S. Geological Survey
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8600 LaSalle Road
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State and County Agencies

Mr. Glenn Lee Bowers
Executive Director
Pennsylvania Game Commission
Harrisburg, PA 17120

Mr. Robert Rowland
District Engineer
Commonwealth of Pennsylvania
Department of Transportation
200 Radnor-Chester Road
St. Davids, PA 19087

Dr. Maurice Goddard, Secretary
Pennsylvania Department of
Environmental Resources
Evangelical Press Building
Third & Reily Streets
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Mr. V. M. Beard, Director
Bureau of Resources Programming
Department of Environmental Resources
Commonwealth of Pennsylvania
P. O. Box 1467
Harrisburg, PA 17120

Mr. Kenneth A. Bartal, Chief
Division of Water Supply and Sewerage
Department of Environmental Resources
Commonwealth of Pennsylvania
P. O. Box 2063
Harrisburg, PA 17120

Director
Chester County Soil Conservation District
Courthouse
West Chester, PA 19380

Director
Delaware County Soil Conservation District
1671 N. Providence Road
Media, PA 19063

Mr. David C. Yaeck
Executive Director
Chester County Water Resources Authority
314 Farmers & Mechanics Building
West Chester, PA 19380

Mr. Ralph A. Abele
Executive Director
Pennsylvania Fish Commission
R. D. #1, Box 70
Bellefonte, PA 16823

Mr. Albert L. Hydeman, Jr.
Secretary
Commonwealth of Pennsylvania
Department of Community Affairs
Box 155
Harrisburg, PA 17120

Mr. John McSparren, Chief
Division of Comprehensive
Resources Programming
Department of Environmental
Resources
Commonwealth of Pennsylvania
P. O. Box 1467
Harrisburg, PA 17120

Mr. Walter A. Lyon, Director
Bureau of Water Quality Management
Department of Environmental Resourc[illegible]
P. O. Box 2063
Harrisburg, PA 17120

Pennsylvania State Clearinghouse
Governor's Budget Office
Intergovernmental Relations
Division
P. O. Box 1323
Harrisburg, PA 17120

Mr. H. Edward Miles
Associate Director
Delaware County Planning Commission
Fronefield Building
Media, PA 19063

Mr. George W. Fasic, Director
Chester County Planning Commission
County Courthouse
West Chester, PA 19380

Mr. Charles Keeler
Chairman, Delaware County Council
Delaware County Court House
Media, PA 19063

Municipal Representatives

Mr. Mark Lamer, President
Board of Commissioners of Aston Township
233 Pennell Road
Aston, PA 19014

Mr. Harold S. Jones
Chairman, Board of Supervisors
of Birmingham Township
Municipal Building
Chadds Ford, PA 19317

Mr. Charles J. Catania
City Engineer
City of Chester
Chester, PA 19013

Honorable John J. Kelly, Sr.
Mayor of Chester Heights Borough
Chester Heights, PA 19017

Mr. Robert Wilson
Chairman, Board of Supervisors
of Edgmont Township
Municipal Building
Gradyville, PA 19039

Mr. Frederick P. Glazier
Chairman. Board of Supervisors
of Thornbury Township
Municipal Building
Thornton, PA 19373

Mr. Thomas Roberts
Chairman, Board of Supervisors
of Upper Chichester Township
Municipal Building
Boothwyn, PA 19061

Mr. Burgess H. Rhodes
Chairman, Board of Supervisors
of East Goshen Township
1580 Paoli Pike
West Chester, PA 19380

Honorable Raymond Phillips
Mayor of Parkside Borough
Chester, PA 19013

Mr. Vernon B. Booth
Chairman, Board of Supervisors
of Bethel Township
Municipal Building
Boothwyn, PA 19061

Mr. William Eppright
Chairman of Borough Council
Brookhaven Borough
Chester, PA 19013

Honorable John H. Nacrelli
Mayor of City of Chester
Chester, PA 19013

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Mr. Donald B. Roberts
Chairman, Board of Supervisors of
Concord Township
Municipal Building
Glen Mills, PA 19342

Honorable Frank DiMaio
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Municipal Building
Upland, PA 19013

Mr. Henry L. Armstrong, II
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Mr. Carl Kulp
Chairman, Board of Supervisors
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Mr. John D. Flagg
Township Manager of West Goshen Township
1025 Paoli Pike
West Chester, PA 19380

Mr. Robert Shaw
Manager of West Chester Borough
15 South High Street
West Chester, PA 19380

Mr. H. R. Stokes
Chairman, Board of Supervisors
of Westtown Township
Westtown, PA 19395

Honorable Robert E. Lambert
Chairman, Board of Supervisors
1025 Paoli Pike
West Chester, PA 19380

Honorable J. Herbert Chambers
Mayor of West Chester Borough
15 South High Street
West Chester, PA 19380

Mr. George S. DiFrancesco
Chairman, Board of Supervisors
of West Whiteland Township
222 N. Pottstown Pike
P. O. Box 210
Exton, PA 19335

EXHIBIT 7

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
112 West Foster Avenue
State College, PA 16801

August 4, 1978

Colonel Harry V. Dutchyshyn
Philadelphia Corps of Engineers
Custom House, 2nd & Chestnut Streets
Philadelphia, PA 19106

Dear Colonel Dutchyshyn:

This responds to Mr. F. W. Vinci's letter of July 27, 1978 concerning the feasibility of flood protection in Chester Creek Basin, Chester and Delaware Counties, Pennsylvania. The Fish and Wildlife Service agrees with your recommendation that no federal project be authorized for flood control in Chester Creek Basin. We support your suggestion for a floodplain management program and do not oppose clearing the channel under existing bridges.

We appreciate working with your staff on this project study. Please keep us informed if further studies are undertaken.

Sincerely yours,

Charles J. Kulp

Charles J. Kulp
Field Supervisor

COMMONWEALTH OF PENNSYLVANIA

EXHIBIT 8

DEPARTMENT OF ENVIRONMENTAL RESOURCES
P. O. Box 1467, Harrisburg, Penna. 17120

In reply refer to
RM-R
F 23:5

November 19, 1973

Worth D. Phillips, Chief
Engineering Division
U. S. Army Engineer District,
Philadelphia
Corps of Engineers
Custom House - Second & Chestnut Sts.
Philadelphia, Pennsylvania 19106

Dear Mr. Phillips:

As you already know, our Department is extremely interested in a study which will address the flood control problems in the Chester Creek Basin. We are very anxious for solution alternatives to be developed for the flood problems in this basin in order that project implementation can be gotten underway as soon as possible.

We do not feel that a metropolitan study will be appropriate for this basin because the State Water Plan and the Comprehensive Water Quality Management Plan will meet these planning needs. There is a need, however, to examine the urban runoff problem which we feel has been largely responsible for the increased flooding conditions in this area in recent years. We view the examination of this problem as part of the overall flood control study which is needed.

We have not enclosed the goals and objectives of the State Water Plan as you requested, since we have already submitted this as part of the Christina River Basin Study.

Sincerely yours,

C. H. McConnell, Deputy Secretary
Resources Management

COMMONWEALTH OF PENNSYLVANIA

DEPARTMENT OF ENVIRONMENTAL RESOURCES
P. O. BOX 1467
HARRISBURG, PENNSYLVANIA 17120

The Secretary

EXHIBIT 9

In reply refer to
RM
F23:5

August 28, 1978

Col. James G. Ton
District Engineer
Philadelphia District - Corps of Engineers
Custom House - Second and Chestnut Streets
Philadelphia, PA 19106

Dear Colonel Ton:

Reference is made to the letter received from F. W. Vinci, Acting Chief, Engineering Division, dated July 27, 1978, requesting our comments on the Draft Report of the feasibility of providing flood protection for the Metropolitan Chester Creek Basin, Chester and Delaware Counties, Pennsylvania, which was transmitted with his letter.

In view of the forty-seven (47) plans considered by the Corps for preventing or reducing flood damages and the threat to human life, we are somewhat disappointed that from these many alternatives not even one economically justifiable and environmentally sound flood protection project could be developed which was acceptable to all interests. We do feel, however, that in identifying and evaluating so many flood protection plans the Corps has taken whatever action is within its authority to assure a comprehensive study of the feasibility of flood protection in the Metropolitan Chester Creek Basin.

The following comments and corrections to the Report are offered for your consideration.

(1) All references in the report should be Subbasin rather than Sub-Basin.

(2) "State Water Plan" should be replaced with "final report" on page 4, line 30.

(3) On page 7, next to last line, laong should be along.

(4) On page 13 under the Water Supply section, the number 257 should be changed to 227.

(5) Under Study Objectives on page 14 change "Pennsylvania . . . Chester Creek Basin" to "Pennsylvania is undertaking a regionalized approach to needed water supply planning in the Chester Creek Basin."

(6) On page 15, replace the first paragraph with the following: DER, in its "State Recreation Plan", has inventoried recreation and open space areas in the Commonwealth; has prepared recreation plans for the Commonwealth; and has formulated planning alternatives and recommendations.

(7) Under Study Objectives on page 15, delete the word "full".

(8) Under Study Objectives on page 16, delete the word "full".

(9) On page 29, line 3, change "selected are" to "selected as".

(10) On page 42a, line 29 under Institutional Studies "flet" should be "felt".

(11) On page A-7, line 10, change "State Water Plan" to "final report".

(12) Add Water Resources Bulletin, Bulletin No. 12, "Low Flow Characteristics of Pennsylvania Streams," to the listing on page B-32.

(13) On page C-4, line 19, change "The draft Pennsylvania State Water Plan" to "Pennsylvania's Comprehensive Water Quality Management Plan".

(14) Under Study Objectives on page C-8, line 3, delete the word "full".

(15) Under Study Objectives on page C-8, delete the sentence beginning with "The Commonwealth" on line 5 and ending with "Basin" on line 7.

(16) On page C-9, under the Public Water Supply section, change the number 257 to 227.

(17) On page C-9, change the chart at the bottom of the page to read as follows:

| | Phila. Sub. Water Co. | Chester Water Auth. | Media Mun. Water Works | West Chester Mun. Auth. |
|---|---|---|---|---|
| Residential | 61% | 18% | 73% | 59% |
| Commercial | 13 | 5 | 7 | 0 |
| Industrial | 10 | 49 | 2 | 25 |
| Other | 3 | 1 | 4 | 15 |
| Bulk Sales | 0 | 12 | 0 | 0 |
| Leaks or Loss | 13 | 15 | 14 | 1 |

(18) On page C-10, Table C-1, make the following corrections:

(a) Delete "26.104" under the column Average Daily Water Use.

(b) Delete "and Purchase" under the column Sources.

(c) Delete "Includes Well" under the column Treatment Plant Capacity.

(19) On page C-10, Table C-2, change the number "6.024 under the column Allocation Deficiency to read "8.832".

(20) On page C-11, change the chart to read as follows:

| Year | Phila. Sub. Water Co. | Chester Water Auth. | Media Mun. Water Works | West Chester Mun. Auth. |
|---|---|---|---|---|
| 1970 | 1.271* | 2.179 | 1.653 | 5.262 |
| 1980 | 1.028 | 1.693 | 1.292 | 3.919 |
| 1990 | 0.874 | 1.451 | 1.043 | 2.968 |
| 2000 | 0.775 | 1.320 | 0.873 | 2.386 |
| 2020 | 0.635 | 1.149 | 0.653 | 1.709 |

*Supply divided by demand ratios are unpublished, therefore, subject to revision. SOURCE: Pennsylvania Department of Environmental Resources.

(21) On page C-11, paragraph 33, change the word "adverse" to "drought".

(22) On page C-13, paragraph 39, change the last four (4) lines of this paragraph to read: "Pennsylvania is undertaking a regionalized approach to needed water supply planning in the Chester Creek Basin".

(23) On page C-14, paragraph 43, change "(DER) is presently developing recreation plans" to "(DER) is presently examining recreation needs".

(24) On page C-16, paragraph 51, change "open space and recreation facilities" on line 18, to "water resource related recreation facilities".

(25) On page C-16, change entire paragraph 53 to read "DER, in its 'State Recreation Plan,' has inventoried recreation and open space areas in the Commonwealth; has prepared recreation plans for the Commonwealth; and has forumulated planning alternatives and recommendations".

(26) On page C-17, Table C-3, make the following corrections:

(a) The title of the chart should read "Water Resource Related Recreational Supply and Demand".

(b) All the figures after Fishing should be multiplied by 1,000.

(27) Under Study Objectives, page C-19, paragraph 57, make the following corrections:

(a) Delete "in the State Water Plan" from the first sentence.

(b) Delete the last seven (7) lines beginning with the sentence "Following a series . . .".

(28) Under Study Objectives, page C-22, paragraph 67, change "that it wished to assume full" to "that it would assume".

We appreciate the opportunity to comment on this study.

Sincerely yours,

Maurice K. Goddard

MAURICE K. GODDARD

EXHIBIT 10

COUNTY OF DELAWARE
COURT HOUSE
MEDIA, PENNSYLVANIA 19063

A C 215-891-2381

FAITH RYAN WHITTLESEY
CHAIRMAN
CHARLES C. KEELER
VICE CHAIRMAN
WILLIAM A. SPINGLER

August 15, 1977

OFFICE OF THE PLANNING DEPARTMENT
WILLIAM H. BATES
CHAIRMAN
THOMAS J. JUDGE
VICE CHAIRMAN
HAROLD F. JONES
SECRETARY

Victor A. Marcus
Lieutenant Colonel
United States Corps of Engineers
Acting District Engineer
Department of the Army
Custom House
2nd & Chestnut Streets
Philadelphia, Penna. 19106

REF: NAPEN-R
Chester Creek Basin Study

Dear Colonel Marcus:

The Delaware County Council adopted the attached Resolution at its regular meeting on August 9, 1977. This Resolution requests that the Corps continue its technical assistance to Delaware County in developing non-structural solutions to problems of flood damage on the Chester Creek.

The non-structural solutions developed by the Corps as part of its Phase II study, have attracted the interest and support of municipalities in the creek basin.

At the request of the Delaware County Planning Commission, and the city of Chester, Council is also requesting that the Corps continue study of two structural alternatives proposed within the City of Chester. It is our understanding that these projects represent alternatives to the reduction of flood damage problems within the City of Chester. The Corps is requested to study both alternatives to determine which, if either, are feasible in terms of economic and environmental considerations.

Finally, Council is requesting that the Corps take no action at this time on the Toby Farms Levee, other than to prepare responses to the concerns raised by the residents of Toby Farms and the elected officials of Chester Township. It is our hope that the Corps will be able to meet once more with the residents of Toby Farms before the end of the year to comment on its proposal. In the event that this program for flood protection of Toby Farms becomes locally acceptable, it is our understanding that it could be accomplished under the Corps small watershed improvement program, which is a different activity from the one which is the funding source for the proposed Chester City structural improvements.

County Council appreciates the cooperation of the Corps in helping to ameliorate our flood problems here in Delaware County, and looks forward to a continuing cooperative relationship.

Please feel free to call upon myself, or H. Edward Miles, Associate Director, for further information concerning these projects.

Very truly yours,

Leon Levine

Leon B. Levine, AIP
Executive Director, DCPD

LBL/jr

cc: Faith R. Whittlesey, Chairman
Representative Robert Edgar
Representative Richard Schulze

EXHIBIT 11

NAPEN-R

7 OCT 1977

Mr. Leon B. Levine
Executive Director
Delaware County Planning
Department
Court House
Media, PA 19063

Dear Mr. Levine:

This is in reply to your letters of 15 August and 2 September 1977 regarding non-Federal sponsorship of flood control plans for the Chester Creek Basin. We have given careful consideration to the County's requests regarding both non-structural and structural plans. Our plans for future work are outlined below.

We accept County sponsorship of the two plans in the City of Chester (Plans S3A & L6C). We are presently conducting further studies on these plans, and will keep you informed of our findings.

Due to the lack of local sponsorship and opposition by Chester Township officials and residents of the area, the Toby Farms levee plans (Plans L8A & L8B) have been eliminated from further consideration. If at some time in the future conditions change, the County can request that the project be reconsidered.

We have not received assurances for the levee and floodwall plans at Lenni (Plans L10A & L10B). In addition, the plans involving an up-stream reservoir combined with downstream protection measures (Plans S4A, S4B, & S4C) were not supported. Since a non-Federal sponsor can not been identified, these plans can not be considered further.

We will not be investigating the development of plans for stormwater management (on-site collection and retention) or flood plain mapping and zoning of flood hazard areas. Neither of these plans had been proposed for Federal implementation. The Federal Insurance Administration (FIA) through the National Flood Insurance Program provides flood plain mapping and flood hazard zoning information to individual

nunities. We will provide existing data which may be used to
ntify flood hazard areas until FIA's information becomes available.

further work will be done on the Flood Insurance plan (Plan FI1).
motion of the National Flood Insurance Program is a local respon-
ility. However, we will provide the County with the results of
investigations.

County has not provided sponsorship for the flood proofing and
od warning plans (Plans FP1 & FW1). We can not continue with them
part of the feasibility study since they will not be recommended
Federal implementation. However, we will consider your request
further analysis of these plans, so they may be implemented by local
erests. This work will be scheduled into our work program for
cal Year 1978. Within the next few months we will advise you
to what we can do in regard to these plans.

ould you have any questions on our current actions or the study in
eral, please contact Mr. James J. Smyth or Mr. Paul Gaudini of my
anning Branch. Both can be reached at (Area Code 215) 597-4714.

Sincerely yours,

WORTH D. PHILLIPS
Chief, Engineering Division

Furn.
. Faith Ryan Whittlesey
. H. Edward Miles
. Charles J. Catania, City Engineer
ity of Chester

RESOLUTION EXHIBIT 12

WE, the Borough Council of Chester Heights, do hereby signify our opposition to each and every one of the Army Corps of Engineers Chester Creek Basin Flood Control Plans that include the Dry Reservoir, designated as R-10, on the West Branch of Chester Creek. Our opposition to this Reservoir stems from the fact that its detrimental social, environmental and economic effects on our Community do not appear to be offset by any local benefits.

Some of the anticipated detrimental effects are here listed:

1. Several residents of the area would be displaced from homes in which they have lived for nearly half a century.
2. At least one house of historic significance would be lost.
3. The existing right-of-way and trackage of the Octoraro Branch, over which SEPTA plans to bring rail service to the area, lies partly within the limits of the proposed Dry Reservoir.
4. A package sewage disposal plant, that currently serves half the residents of Chester Heights, may be rendered unserviceable.
5. Our main traffic artery, Valleybrook Road, lies partly within the boundaries of the Reservoir, with topography in the area that precludes the possibility of re-locating the road.
6. In times of moderate flooding, portions of every road in the southern part of the Borough would be submerged, rendering all north-south traffic movement impossible.
7. The interceptor line, proposed by Delcora for the West Branch of Chester Creek would follow the center line of the reservoir.
8. The two main feeder lines of the Chester Water Authority lie within the Reservoir for its entire length.

In substance, our Community refuses to be periodically inundated for projects of questionable efficacy, designed solely to ameliorate flooding effects in downstream areas that should never have been allowed to develop.

RESOLVED this 7th day of February, 1977.

COUNCIL OF THE BOROUGH OF CHESTER HEIGHTS

John W. deCampi, President

John J. Kelly, Sr., Mayor

ATTEST:

H. Herbert Breneman, Secty

Appendix 2

EXHIBIT 13

Address All Communications to the Secretary
1327 Peterson Street, Chester, Pa. 19013
Phone: 494-4149

# Township of Chester

COUNTY OF DELAWARE
PENNSYLVANIA

REGULAR MEETINGS
First Thursday of each month

FRANCIS P. CONNORS, Solicitor
211 N. Olive Street
Media, Pa. 19063

BOARD OF SUPERVISORS
ROBERT C. WILSON, JR., President and Roadmaster
EDGAR A. GREEN, JR., Vice-Pres.
JOSEPH A. PALAZZO, Sec'y & Treas.
MRS. HELEN L. EVANS, Twp. Director
CHARLES CATANIA, Engineer

TOWNSHIP OFFICIALS
JOSEPH GUARANTE
Building Inspector
C. W. MAYO, JR.
Plumbing Inspector
I. WILLIAMSON
Electrical Inspector
E. A. WILLARD
Tax Collector
60 Concord Rd.
Chester, Pa. 19015

August 12,1977

United States Army Corps of Engineers
Custom House
2nd & Chestnut Sts.
Philadelphia, Pa. 19106

Attn: Paul Gaudine

Dear Mr. Gaudini:

This letter pertains to your flood control study of the Chester Creek and specifically your proposal to construct a levee along the creek at the location of Toby Farms. As a result of several meetings with residents and a door-to-door poll we have concluded that a large majority of the affected residents object to the proposed levee. We therefore have adopted an official position opposing such construction and do not wish to sponsor the project.

We appreciate the efforts that the Corps has made in studying flooding problems within the Township and if we can be of any assistance in your efforts do not hesitate to contact us.

Very truly yours,

Robert C. Wilson/eac

Robert C. Wilson, Jr.
President

RCW/eac

EXHIBIT 14

# TOWNSHIP OF CONCORD

DELAWARE COUNTY
Box 171, Concordville, Pa. 19331
Phone (215) GL 9-8911

BOARD OF SUPERVISORS
JOHN T. KENNEDY, JR.
DONALD B. ROBERTS
CHARLES SHORE
LAURENCE G. SOPER, JR.
CHARLES J. UPPERMAN
MEETING NIGHT - 1ST MONDAY

JOHN W. CORNELL
TOWNSHIP MANAGER
G. D. HOUTMAN & SON
TOWNSHIP ENGINEER
JOHN W. WELLMAN
TOWNSHIP SOLICITOR

May 3, 1977

Department of the Army
Philadelphia District, Corps of Engineers
Custom House - 2nd & Chestnut Streets
Philadelphia, Pennsylvania 19106

Attention: Mr. Paul Gaudini

Re: Stage II Findings On Alternative Plans For Flood Control

Dear Mr. Gaudini:

Be advised that the Concord Township Board of Supervisors at their regularly scheduled meeting of May 2, 1977 unanimously approved a motion to reject alternatives S4A, S4B, & S4C of the Stage II Findings On Alternative Plans For Flood Control.

The following are the reasons for the Board of Supervisors turning down the dry reservoir alternatives as outlined by the Army Corps of Engineers:

1. High local share of the proposed project costs;
2. Preservation of local historical sites and buildings;
3. Displacement of local residents;
4. Potential disruption of local traffic circulation;
5. Protection of local health, welfare, and safety.

Other alternatives as outlined in your report are not commented upon in that they do not directly impact upon Concord Township. I am referring to down stream alternatives as documented in your report.

Please contact me if I can provide you with any further information.

Sincerely yours,

John W. Cornell
Township Manager

JWC/avj
cc: Aston Township
Chester Heights Borough
Concord Township Board of Supervisors

EXHIBIT 15

Borough of Upland

Office of the Secretary
Borough of Upland
Municipal Building
Upland, Pennsylvania

Upland, Pennsylvania

Phone
Fremont 4-7317

May 10, 1977

The U. S. Army Corps of Engineers
2nd and Chestnut Streets
Philadelphia
Pennsylvania 19106

ATTENTION: A.P.E.N. - R, Chester Creek

Gentlemen:

Upland Borough Council, at its meeting May 3, 1977 expressed its support for the flood protection measures along Chester Creek. However, Council feels that they will not be financially able to assist in the project. They request that the local share funding be incorporated into the overall federal program. In addition, Council requests the immediate Corps action in having the Chester Creek channel dredged and cleaned of debris within the Borough limits.

Very truly yours,

Donald G Schwolow

Donald G. Schwolow
Borough Manager/Secretary

DGS/aa
cc: Senator Richard S. Schweiker
Senator John Heinz
Congressman Robert Edgar
Congressman Richard T. Schulze

# METROPOLITAN
# CHESTER CREEK BASIN
# PENNSYLVANIA

## REPORTS OF
## OTHER AGENCIES

APPEND

# APPENDIX 3

## REPORTS OF OTHER AGENCIES

TABLE OF CONTENTS

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Center Building, Room 225
6816 Market Street
Upper Darby, Pennsylvania 19082

November 20, 1975

District Engineer, Philadelphia District
U. S. Army Corps of Engineers
Custom House - 2nd & Chestnut Streets
Philadelphia, Pennsylvania 19106

Dear Sir:

This constitutes our preliminary report on the fish and wildlife resources of Chester Creek Basin, Chester and Delaware Counties, Pennsylvania. The study was authorized by a resolution of the Committee on Public Works of the U. S. Senate and House of Representatives, adopted November 2 and December 2, 1971, respectively. This report has been prepared under the authority and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

This report contains general descriptions of fish and wildlife resources, their habitats and related needs, problems and possible solutions. The information is presented to provide your agency with pertinent fish and wildlife aspects for consideration in development of plans for the Chester Creek Basin.

Purposes of the study are to develop a plan for flood control which will include structural and nonstructural measures to solve flooding problems. Such measures to be considered include dams, levees, flood walls, stream channelization, and flood plain management. Overall study objectives will encompass evaluations of plans to meet requirements set forth in the Water Resources Council's "Principles and Standards".

Chester Creek Basin is a small watershed encompassing some 67 square miles within the suburbs of Philadelphia, Pennsylvania. Approximately 32 percent and 68 percent of the watershed lies within Chester and Delaware Counties, respectively. Topography is gently rolling with low hills and ridges.

CONSERVE AMERICA'S ENERGY

*Save Energy and You Serve America!*

Approximately 20 percent of the watershed is in immature forest consisting of deciduous hardwood types common to southeastern Pennsylvania. Principle species include red oak, black oak, beech, and tulip poplar. Most of the remainder of undeveloped lands are hay fields, pastures or cultivated small grains.

Chester Creek originates in the rolling hills near the Borough of West Chester. It flows southeasterly approximately 36 miles to its confluence with the Delaware River at Chester, Pennsylvania. The lower 3.5 miles of the stream is tidal. Major tributaries are West Branch, Chrome Run, Rocky Run, Goose Creek, and East Branch.

Although annual precipitation of 42 inches is evenly distributed throughout the year, stream flows vary because of water supply diversions both in and out of the watershed. The 40 year average flow at the mouth of Chester Creek was 80.4 cfs according to the U. S. Geological Survey gauging station. Recorded flows ranged between a maximum of 33,700 cfs in 1971 to a minimum 0.3 cfs in 1934.

Water quality of some tributaries and sections of Chester Creek is presently severely degraded. Heavy industrial and domestic pollution plus contaminates from urban areas are particularly severe in the lower basin at the City of Chester. Streams within the upper two-thirds of the watershed are degraded in segments near municipalities and rural housing developments as the result of domestic sewage, high nutrient lands from applied fertilizers and excessive sedimentation from land disturbance.

Water quality standards established by the Pennsylvania Department of Natural Resources have been established for basin streams. Application of measures to upgrade present degraded conditions is expected to result in improved water quality in the foreseeable future. In addition, the Basin is subject to the Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500 which will require Federal regulations and permits to discharge effluents and deposit erodible materials within streams and flood plains.

Population within the Basin totaled 113,116 according to the 1970 U. S. Bureau of Census. The City of Chester (lower basin) accounted for almost 50 percent of the population and the Borough of West Chester (upper basin) amounted to 17 percent. Excluding the two major urban centers, population density of the remaining watershed averaged 555 per square mile in 1970. Present trends indicate extensive expansion within the Basin with major emphasis on housing and shopping centers.

Fishery resources within the Basin consist of both warm-water and coldwater species.

Streams suitable for trout are Chester Creek (11.3 miles), West Branch (7.0 miles), and East Branch (1.2 miles) totaling 19.5 miles. One of the better trout areas runs from near Cheyney to Glen Mills. This area is well shaded and contains boulders and logs which provide fish habitat. Warmwater stream fisheries occur throughout the remaining streams or sections within the Basin but are limited due to pollution. Principle stream fish species include trout, smallmouth bass, bullhead, sucker, eel, and sunfish.

Twelve impoundments, totaling 135 surface acres, comprise the impoundment type fisheries. These, together with pertinent information are listed in Table 1. Principle sport fishes produced within the impoundments include largemouth bass, bluegill, crappie, and bullhead.

Fishing opportunities are extremely limited within the basin in relation to high demands from human populations within the basin and surrounding metropolitan Philadelphia. Therefore, the few miles of suitable fishing streams and the small acreage of impoundments are subject to excessive fishing pressure in relation to the resource capabilities. Although fishing pressure far exceeds the annual supplies produced, it is estimated that existing annual productive capabilities of the streams and reservoirs afford 54,800 fisherman-days at a harvest level at ½-pound of fish per day.

Fishing demands within the basin, calculated on basis of the 1970 National Survey of Fishing and Hunting, are estimated at 330,000 fishing days annually. Subtraction of the 54,800 man-days in resource capability leaves 275,200 days in unsatisfied demand.

## Table 1 - Dams and Reservoirs of Chester Creek Basin

| Name of Dam | Drainage area (square miles) | Acres | Storage (acre-feet) | Use* |
|---|---|---|---|---|
| Townshipline Dam | 2.9 | 65.0 | 628.0 | 1 |
| Milltown Dam | 6.6 | 12.0 | 67.0 | 1 |
| Westtown School Lake | 6.4 | 13.0 | 1.5 | 2 |
| Unnamed Dam | 1.1 | 14.0 | 31.0 | 2,3 |
| Concord Mills | 5.1 | 0.5 | 1.5 | 1 |
| Brinton Lake Dam | 17.1 | 9.0 | 15.0 | 2 |
| Lennie Dam | 36.1 | 16.0 | 1.5 | 4 |
| Cotton Mill Dam | 36.6 | 4.0 | 1.5 | 4 |
| Unnamed Dam | 19.0 | 0.5 | 1.5 | 4 |
| Llewellen Mill | 18.0 | 0.5 | 1.5 | 4 |
| Rockdale Dam | 56.0 | 0.5 | 6.1 | 4 |
| Plant No. 3 | 18.5 | 0.5 | 1.5 | 4 |
| T O T A L S | 223.4 | 135.5 | 757.6 | |

* Use
1. public water supply
2. recreation, pleasure, fish propagation, landscape
3. electric power generation
4. water power-mechanical

Appendix 3
4

The principle problems related to meeting fishing needs include (1) lack of resource areas to provide fishing opportunities, (2) degradation of existing fishery habitats resulting from inadequate treatment of individual, domestic wastes, (3) excessive erosion and sedimentation resulting from housing, roadway construction and poor land stabilization, (4) stabilization of stream flows and fish food supplies, and (5) insufficient public access to fishing areas due to private development and posting.

The foregoing problems can be alleviated through provisions of specific measures in a comprehensive multiple-purpose basin plan, designed to preserve and improve fishery resources. Such a plan should include water quality improvement measures, flood plain zoning and set limits on instream flows apportioned to different uses, including fish and wildlife resources.

Early implementation of specific measures for improved treatment of industrial and domestic wastes to meet established water quality standards would result in significant expansion of stream fisheries within the Basin. These measures, together with rigid enforcement of erosion control at all land disturbed areas (housing sites, exposed roadsides, etc.) would be necessary to achieve effective stream improvement.

The basin fish and wildlife resources are restricted to adaptable species. White-tailed deer is the only big game species in the basin. It is more abundant in the upper part of the watershed than other sections but nowhere occurs in large numbers. Deer hunting is limited by land posting, local ordinances against gunning and extensive development of the watershed.

Gray squirrels are common throughout the basin. They are most numerous in mature woodlots. They provide some hunting but may be more valuable for aesthetic reasons. Cottontail rabbits are also hunted but also provide enjoyment for many suburbanites. They are more common along forest edge or around homes with good shrubbery habitats.

Ringnecked pheasants, quail, and doves are the three major gamebirds of the area. All are associated with farmlands though doves are also found in suburban and

urban areas. Hunting these birds is restricted by local ordinances and extensive posting.

Fox hunting with horses and hounds is a popular sport in the basin. Raccoons and muskrats are the most abundant furbearers although they are more valuable for aesthetics and environmental education than for furs. Opossum, skunk, and weasel also occur but none are extensively harvested.

Basin waterfowl habitat is limited to ponds, reservoirs, and some stream sections. Hundreds of Canada geese migrate through the area and rest on larger impoundments. Grain fields are attractive feeding areas to these migrating birds, particularly if the fields are near water. Mallards are the predominate duck species though wood ducks and black ducks also occur. The ducks utilize most open water areas of the basin. A small area of wetlands exists near Cheyney which could be valuable to waterfowl and other wildlife species if properly managed. Woodcock are found in swampy areas or bogs, such as the area near Cheyney, which provide the essential food of earthworms.

Hunting within the basin is severely restricted due to urban sprawl and associated development and land posting. Estimated from the 1970 National Survey of Hunting and Fishing, the basin supports a demand for 99,000 hunter-days. Little of this demand is satisfied within the basin. Limited areas of the basin are open to hunting but usually only to landowners or their personal guests.

Other wildlife-related activities are popular in the basin. Based on the 1970 Survey of Outdoor Recreation Activities, the basin would have an estimated 2,500 bird and wildlife photographers, 3,800 bird watchers, and about 15,000 persons who take nature walks each year. The 1968 Open Space Report by the Citizens Council of Delaware County concluded that with a minimum of 10 acres of open space per 1,000 persons, Delaware County lacked 11,400 acres to meet these standards in 1970. If present trends continue, open space in the watershed will be depleted and consequently the fish and wildlife resources will diminish.

Delaware and Chester Counties are both considered within the range of the threatened bog turtle. Bog turtles prefer grassy, murky, shallow swamps and are frequently associated with sphagnum bogs. The southern bald eagle, an endangered species, is a possible accidental record for the area. We are not aware of recent confirmed records of either species inhabiting the watershed.

Chester Creek basin offers good opportunities to develop environmental education areas in combination with structural or nonstructural flood control measures. Such facilities would be valuable to non-consumptive wildlife users and possibly fishermen.

Reservoirs greater than 10 feet deep and about 100 acres in size would be heavily utilized by fishermen and other water-dependent recreationists. Existing reservoirs and stream areas should also be open to public use.

We appreciate the cooperation of your staff and look forward to further contact in future project stages.

Sincerely yours,

Michael T. Chezik

Michael T. Chezik
Acting Supervisor
Central Area Office
Division of Ecological Services

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
112 West Foster Avenue
State College, PA 16801

July 14, 1977

Colonel Harry V. Dutchyshyn
District Engineer, Corps of Engineers
Custom House, 2nd and Chestnut Streets
Philadelphia, PA 19106

Dear Colonel Dutchyshyn:

This interim report concerns the proposed flood control plans for the Chester Creek Basin, Chester and Delaware Counties, Pennsylvania. This report has been prepared in accordance with the Fish and Wildlife Coordination Act, P.L. 85-624.

The purpose of this report is to provide general information about the impacts of proposed alternative flood control plans on fish and wildlife resources in the Chester Creek Basin. The Fish and Wildlife Service provided a preliminary report on the project plan dated November 20, 1975 and a planning aid letter on February 15, 1977. Our comments on current project plans are as follows.

## Non-Structural Alternatives

Seven of the forty-seven proposed alternatives are non-structural. These include no action, flood insurance, permanent floodplain evacuation, flood forecasting and flood proofing. Of these alternatives, only floodplain evacuation could adversely affect fish or wildlife resources in the form of construction required for new housing or businesses. Non-structural alternatives generally have insignificant impacts on fish or wildlife resources and, therefore, are encouraged by the Fish and Wildlife Service.

## Bridge Modifications and Associated Channelization

Several of the alternatives involve the widening of bridges and enlargement of the channel under bridges in the City of Chester. These projects would have minor impacts on fish and wildlife resources due to the stressed conditions already found in the area. Some increases in turbidity and loss of riparian vegetation could be expected, however. Chester Creek has a

potential to provide spawning and nursery habitat for anadromous fish such as American shad and blueback herring. Therefore, no work should be undertaken which would inhibit fish passage through the lower portion of the stream. Erosion control techniques should be implemented immediately after constructing to reduce turbidities during the principle migratory period (April 1 to June 30).

Since riparian habitat in Chester is sparse, every effort should be made to preserve existing vegetation along streams proposed for channel work. This could be done by limiting work to one side of the stream and replanting disturbed areas with species such as willow, dogwood and red mulberry which shade the stream and provide urban wildlife habitat. If channels are constructed which isolate oxbows, they should be built as flood bypass channels. This would reduce impacts to the stream and open areas during non-flooding periods. No known species of endangered or threatened fish or wildlife are known to occur in this area.

## Channelization

The extensive channelization proposed in plans L7A, L7B, L7C and L7D would result in significant losses to fish and wildlife habitat.

The vegetation which currently grows along Chester Creek is used by a variety of song birds, small mammals and other wildlife common to urban and suburban environments. A list of species observed during a field investigation on June 23, 1976 is provided in the attached Table 1. Mammals observed along Chester Creek in June 1976 include muskrat, cottontail rabbit, gray and red squirrel, striped skunk, raccoon and opossum. Reptiles and amphibians observed include bullfrog, painted turtle, eastern blacksnake and northern watersnake. In addition to providing wildlife habitat, the vegetation improves air quality in the area by filtering pollutants and producing oxygen. It also serves as a visual barrier to urban blight. Other species collected during the field investigation include mummichog, banded killifish, satinfin shiner, white sucker, spottail shiner and blue crab.

Although the portion of Chester Creek downstream from the Baltimore Pike is abused and degraded, it is fished nearly the entire length to the Delaware River. Carp, goldfish, eel and bullhead make up the majority of the resident fish species taken. This stretch also provides hikers, nature lovers and photographers convenient opportunities to escape the stresses of urban and suburban living.

Channelization of the stream would eliminate opportunities to improve fish and wildlife resources in the area. If water pollution control laws continue to be implemented and enforced, fish and wildlife habitat should improve in the area. The Fish and Wildlife Service, therefore, opposes alternatives which involve extensive channelization.

Goose Creek within West Chester Borough, provides little fish or wildlife habitat. Channel work in this area would have little impact on these resources. However, as Goose Creek enters Westown Township, streambank vegetation greatly improves. The stream itself, however, remains grossly polluted by sewerage effluent. No channelization should be planned for the portion of Goose Creek outside West Chester Borough. Instead, pollution control measures should be enforced. No endangered or threatened fish or wildlife species are known to occur in this area.

## Levees and Floodwalls

Levee or floodwall construction would involve some loss of riparian vegetation. This alternative would have lesser impacts than proposed channelization alternatives and the loss of vegetation could be partially offset by replanting. Representative tree species presently found along Chester Creek include sycamore, American beech, ash, silver maple, black willow, tulip, poplar, black walnut, hackberry and black cherry.

Shrub and vine species include spicebush, elderberry, silky dogwood, alder, viburnum, grape, honeysuckle, Virginia creeper and poison ivy. Herbaceous plants include deer-tongue grass, pokeweed, timothy, giant ragweed, redroot cyperus, fleabane, goldenrod, chickoy, milkweed and sensitive fern. With replanting, construction of the levee or floodwall alternatives would have a minimal impact on fish and wildlife resources.

## Dry Reservoirs

The dry reservoir alternatives could be advantageous to fish and wildlife resources by maintaining open areas in public ownership. If these areas were managed to maintain a diversity of habitat, additional benefits could occur. The reservoir sites could serve as natural areas and be used for outdoor education, nature walks, nature photography and other activities. However, if the sites were cleared and maintained in that condition, benefits to wildlife resources would be negligible.

The Fish and Wildlife Service supports the non-structural alternatives and recommends that:

1. Alternatives which involve extensive channelization not be adopted.
2. Bridge modifications and channel work in the City of Chester be conducted with a minimum of disturbance to vegetation.
3. Oxbow cutoffs be constructed as flood bypass channels.
4. Vegetation destroyed by construction of dikes or levees be replaced by planting combinations of plant species similar to existing species. This could be partially on the site or on a nearby site which needs to be revegetated.

We would appreciate a response as to the acceptability of our recommendations by October 30, 1977. Please keep us informed of any changes in the status of the project.

Sincerely yours,

Charles J. Kulp

Charles J. Kulp
Field Supervisor

DATE
FILMED